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Forthcoming Events.

DECEMBER 5.

Stoke-on-Trent Association of Engineers:—Meeting at Stoke-on-Trent. Lecture by W. H. Makepeace.

Institute of British Foundrymen (Lancashire Branch):—Ordinary meeting at Manchester. "Some Metallurgical Features of Electric Steel Castings," Paper by F. A. Melmoth.

Birmingham Metallurgical Society:—Annual dinner at Birmingham.

Institute of British Foundrymen (Lancashire Branch):—Ordinary meeting at Manchester. "Some Metallurgical Points in Electric Steel Castings and Notes on Defects," Paper by F. A. Melmath.

DECEMBER 8.

Institution of Petroleum Technologists:—Ordinary meeting in London. "Oil Well Tool Steel," Paper by P. N. Rogers.

Institute of British Foundrymen (Lancashire Branch, Burnley Section):—Ordinary meeting at Burnley. "Oil, Sand and Production," Paper by Mr. West.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The Foundryman of the Future.

Of the intense interest taken by founders in foundry education the attendance at the recent meeting in Birmingham furnishes ample evidence. The meeting, moreover, attracted in addition a number of distinguished visitors from all parts of the country, the Board of Education being represented, as well as a number of technical schools and other institutions.

Many dire prophecies are current concerning the probability of an acute shortage of moulders and core-makers in a few years' time; and, indeed, the industry already suffers from the scanty number of men within it who have had both practical and technical training.

More than any other industry in the country does founding demand in all its workers a combination of practical and technical knowledge. The only doubtful point is how to secure for each grade of employment the correct combination of these two sides. The knowledge required by the moulder or core-maker is mainly practical, with a sufficient leaven of the technical to give interest and meaning to his everyday work, and to enable him to understand the ultimate effects of any inaccuracy. Under proper conditions, the technical knowledge necessary for this grade can be obtained in the technical schools, and in this connection we are strongly in favour of foundry subjects being taught by those actually engaged in the industry from day to day. We suggest that the practical training can be obtained most satisfactorily in the foundry itself, under a proper superviser, and we favour a short apprenticeship of three or four years' duration. An employer who provides a thorough training will have no difficulty in securing applications from well-educated boys. The most ambitious of these should find it possible to advance steadily to the highest posts the industry has to offer.

The industry also needs the services of well-educated men from the Universities, whose training has been sufficiently broad for them to see the desirability of practical training, too, and means should be found to enable suitable graduates to get this practical side on the foundry floor.

There is room for a good deal of argument as to whether a Foundry Technical School of the character so ably described by M. Ronceray is really needed in this country for the solution of this problem, or whether such a school is suited to the educational conditions prevailing here. We are, however, inclined to think that any experiment in education can be made to justify itself, and the peculiar necessity for co-operation between the technical and practical sides in this case gives ground for the belief that such a school might help to solve some of the difficulties now confronting the industry. Such a school, we feel, would have greatest chance of success if its establishment were to be provided for by both the industry and the State; if it were to have an integral relationship with the Universities and the Technical Schools; and if the teaching were conducted by those founders and metallurgists actively engaged in the industry from day to day. The only restriction on entry should be a simple entrance examination based on practical experience gained in foundries, and appropriate technical knowledge, in which courses should be provided in all large technical schools. It should be open alike to artisans, apprentices, or foremen, both in the ferrous and in the non-ferrous trades, and trained metallurgists and engineers.

We can imagine nothing better for the future of the industry, whether from the technical or from the labour side, than for the ambitious

artisan and the metallurgical graduate to spend a year in the same school, repairing the gaps in each other's experience.

We trust that no time will be lost in the formation of the proposed Committee, and that it will be made thoroughly representative, while remaining small enough to accomplish its work without delay.

The Cast Iron Research Association and the Birmingham, Coventry, and West Midlands Branch of the I.B.F. are to be congratulated on arranging a meeting that should prove a real inspiration to the work of the near future, and that appears in addition to have drawn together so many and such varied interests on a common ground.

Every step that the industry takes to improve the education it has to offer to those seeking entry gives one more reason for optimism as to its future.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Pearlitic Iron.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The discussion in your columns as to pearlitic cast iron is most interesting, but, as you say: "If correspondents would stick to the points at issue better progress would be made." There has been a tendency to lose sight of the quite simple fundamental principle involved, and as the realisation of this principle and its application to practice are of great importance to the foundry industry, may I beg sufficient of your valuable space to outline its details as viewed by a practical metallurgist, with a view to making things clear to practical foundry workers in general, and to a correction of these details by pearlitic iron experts if and where necessary.

Briefly, an ordinary foundry iron cooled slowly from the molten state will, of course, on cold fracture, show most of its carbon in the graphitic condition, the graphite flakes being more or less coarse, and the metallic matrix consisting, essentially, of ferrite and pearlite; the same iron, if cooled sufficiently rapidly (*e.g.*, by drastic chilling), will show on cold fracture all its carbon in the combined condition, the structure consisting essentially of cementite and pearlite.

Similarly, for any given rate of cooling between these extremes, the higher the silicon content, the less of the carbon will be retained in combination—the balance being thrown out as graphite—and *vice versa*.

Thus we have two sets of extremes:—

I. Rapid cooling or low silicon—white iron.

II. Slow cooling or high silicon—grey iron.

The problem in the case of high-duty cast irons to withstand stress and shock (as opposed to friction) is to produce as far as possible a material having:—

(*a*) Its graphitic carbon split up into small nodular flakes and finely distributed, the amount being lower than normal.

(*b*) Its metallic matrix formed of pearlitic grains.

These conditions necessitate a low total carbon content, and various considerations would seem to indicate that results can best be obtained by a combination of *slow cooling* with *low silicon content* (see I and II above). The silicon must, in fact, in many cases, be so low that, to preserve the balance of conditions, cooling must be *very* slow, therefore hot moulds are used. That is the basis of the case put in a simple manner; I neglect many very important incidental influences in order to make essentials clear. Where the Perlit people come in, is that they presumably have thoroughly explored the various "considerations" mentioned above, so for any given casting they can tell you what balance of mould temperature (as determining rate of cooling) and silicon content, also analysis generally, one must observe to obtain the desired structure.

Their calculations, their methods, or the practicability of heating intricate moulds are all matters for fair criticism, but as to the general principle involved there can be no question. A structure of finely nodular graphite set in a pearlitic matrix is the structure of the future. As to whether the Perlit process is the best way of tackling the job it is up to the Perlit Company to prove, and there need be no "mystery" about pearlitic cast iron.

Evenness of structure through thick and thin sections is a most important subject, which requires much ventilating; it would be interesting to have a detailed exposition of the "Perlit" point of view in the matter. I am, sir.—Yours, etc.,

F. D. CORBIN.

Llanelly.

Overseas Guests Entertained.

An extremely interesting and important function was held last Tuesday evening at the Shipping, Engineering, and Machinery Exhibition, at Olympia, when Mr. F. W. Bridges, the organiser, entertained to dinner the overseas visitors. The function was presided over by the Hon. Sir Charles A. Parsons, K.C.B., F.R.S. Visitors were present from New Zealand, Australia, South Africa, Canada, America, Japan, Burma, France and Italy. The date was particularly well chosen, being that of the signing of the Treaty of Locarno. Dr. Hele Shaw, F.R.S., proposed "The World's Navies and Mercantile Marine," to which Capt. James B. Stevenson, the Commonwealth Liaison Officer and Naval Representative, replied. "The Engineering Industry" was proposed by Mr. J. Butler, a prominent saw-mill owner in New Zealand. Mr. Butler, in referring to the supposed lack of interest by British engineers in giving the Dominions machinery specially suited to their needs, pointed out that in many cases the demand was so small as not to warrant the time and energy spent on meeting it.

Mr. D. A. Bremner, in reply, presented some extremely interesting figures to show that the British engineering industry had more than maintained its prestige since the war, and this under exceptionally difficult conditions.

Brigadier-General Mowat, of the Institute of Mechanical Engineers, gave the toast of "Our Guests from Overseas," and commented appreciatively on the action of the Australian Navy in providing work for British shipyards and positions for British naval engineers.

Mr. F. W. Watson, a metallurgist from Johannesburg, replied, and expressed the indebtedness of the Rand mines for the help they had received from the home country.

The Hon. Sir John A. Cockburn, K.C.M.G., an Australian ex-Governor, proposed the toast of "The Chairman."

The London I.B.F. Branch Annual Dinner.

This popular function is to take place at 7.30 for 8 on Friday week, December 11, at the Engineers' Club, Coventry Street. A number of influential gentlemen have promised to be present, including Mr. John Cameron, J.P., the President of the Institute. Foundrymen from overseas or the provinces who anticipate being in London on that date should get in touch with the Honorary Secretary, Mr. H. G. Sommerfield, of Charterhouse Chambers, Charterhouse Square, London, E.C. Foundrymen and others who intend being present at the lectures to be given earlier in the evening by Mr. Pearce and Mr. Fletcher at the Institute of Mechanical Engineers can attend both functions.

London Lecture Time Changed.

Mr. Hoblyn's lecture before a joint meeting of the London Sections of the Institute of Metals and the Institute of British Foundrymen, scheduled to take place at 7.30 at the Institute of Marine Engineers, The Minories, London, E.C., next Thursday, has been retimed to start at 8 p.m. at the same place and date.

Machines in Non-Repetition Foundries.*

By Geo. Edginton, M.I.Brit.F.

In introducing this subject of "Machines in a Non-repetition Foundry," it is probable that foundrymen always associate moulding machines with the production of large quantities of repetition castings. But competition is so keen in these times that founders are turning their attention to machines that will help to produce bigger and more varied type of castings. Already great strides have been made in this direction, which has materially helped to reduce the cost of castings to the customer. Also the skilled moulder is losing some of his conservatism and taking more kindly to these machines, which are helping to cut out some of the drudgery of his trade.

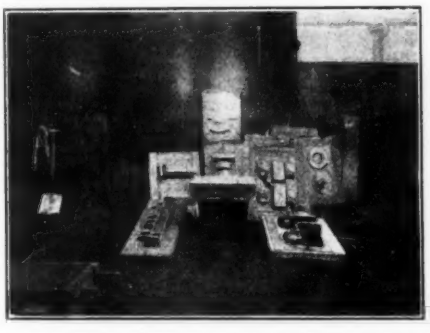


FIG. 1.—SHOWING VARIOUS PATTERN BOARDS AND TYPE OF JOLT MACHINE USED.

The need is becoming greater for the use of machines, as really skilled moulders are getting more scarce as time goes on, and it is therefore essential that machines which can be operated by semi-skilled men after a few weeks' training should be more widely used to meet foreign competition.

The foundry in the past has been badly neglected by the engineer, but the signs are that more attention is being given in this direction, and mechanical appliances are being introduced in many forms. But even in these times one frequently hears practical founders say that their's is a jobbing shop, and therefore can find no use for moulding machines, as the class of work they are producing is too varied, and not enough off to warrant the use of machines. It is not proposed to enumerate all the different types of machines in use at the present time, but to show what the Broadoaks foundry is doing, which may possibly be of some interest and help to those who have not up to the present time given this matter serious consideration.

FIG. 2.—SHOWING A FEW PATTERNS FOR STEEL CASTINGS.

There are numerous kinds of jolting machines, all of which are claimed by their different makers to be the best, but the author is of opinion that the best machine is the one constructed on simple lines, and gives greatest service and efficiency without being in the fitters' hands one or two days each week. The plain jolt machine, without any turning-over gear or other complications, is the one which is favoured at the Broadoaks works. This being a non-repetition shop, is best served by a machine whose only operation is to ram the sand. There are eight machines (Fig. 1) with 6-in. dia. cylinders, the lifting capacity being about 12 cwts., and the table 24 in. × 18 in. The method employed is to have several jobs on plates (Fig. 2), operating simultaneously. For instance, while the operator jolts up one box, a man or boy, according to the job, draws the pattern, so that the machine is kept ramming all the time, and as long as required. From Fig. 3 it will be noticed that the boxes have fairly long pins, and this keeps the pattern quite steady and ensures a good draw. These pins have a slot through which a cotter is passed, and this serves to fasten the box down to the pattern board whilst it is being jolted.

FIG. 3.—A NUMBER OF MOULDS SHOWING THE LONG PINS USED WITH COTTER HOLES.

By not having pattern-drawing arrangement on the machine the necessity is eliminated for machined boxes, which are a considerable cost on the foundry. For making the moulding boxes the jolting machine is also used. This gives them very good faces, which in many cases are almost as good as machined ones. An arrangement (Fig. 4) which has been found to work satisfactorily is to put the hand boxes on benches. The men are able to stand up to their work, and are much more comfortable, and work better than when kneeling in the damp sand on the floor. It is not wished to discredit in any way the excellent arrangements on some machines which are doing the same jobs day by day for weeks at a stretch. There is much to be said for them, but it seems desirable to emphasise that good work can be obtained from jolt machines without any expensive tackle being

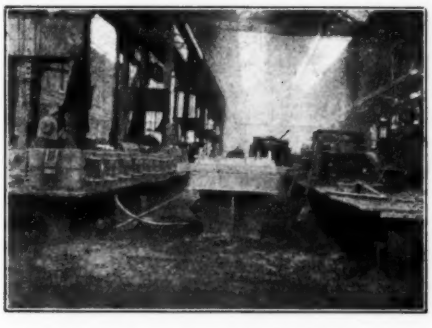


FIG. 4.—SHOWING THE ARRANGEMENT OF BENCHES FOR HAND BOXES INTRODUCED FOR THE PURPOSE OF ELIMINATING THE KNEELING OF MOULDERS IN DAMP SAND.

* A Paper read before the London Branch of the Institute of British Foundrymen, Mr. G. C. Pierce presiding.

first prepared. This will best be illustrated by illustrations of bigger machines in use in the Broadoaks Foundry.

There are two large machines, one with a 20-in. dia. cylinder, capable of lifting 8 tons, another with 16-in. dia. cylinder, which lifts 5 tons, the tables being 6 ft. square. This does not mean that anything longer than 6 ft. cannot be rammed, as

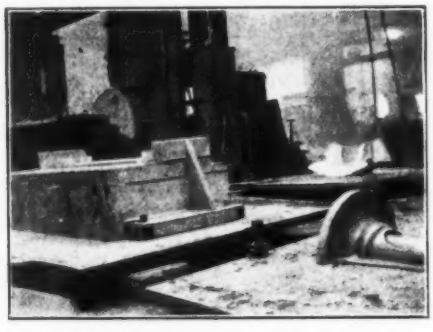


FIG. 5.—HERE THE PATTERNS ARE MOUNTED ON PLATES PREVIOUS TO THE BOXES BEING PLACED OVER THEM.

frequently boxes are used up to 12 and 14 ft. long. Around these machines there are a number of plates of various sizes to take different sized jobs. These have a series of tapped holes 1 in. dia. pitched at equal distances around the edges. This

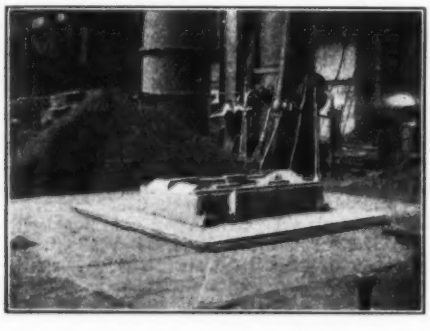


FIG. 6.—A PATTERN MOUNTED ON THE PLATE READY FOR RECEIVING THE BOX.

allows the putting of various size boxes on the same plates, and at the same time ensures being able to fasten down the box. The plates have machined faces, and when the jobs come off the machine they present a perfectly true joint, and the

FIG. 7.—A MOULDING BOX BEING RAMMED ON THE LARGE MACHINE.

moulder has only to draw the pattern. If the job has several off, dowell pins are located along the centre line of the plate, and the patternmaker has jigs, which suit the different lengths of patterns. In most cases no locating pins are used where only one or two castings are required. The two half-patterns are set equally in the box top and bottom. Then before the core is put in the bottom half of the mould the top is set accurately over it and either pinned or marked. The core is then put in and the cope replaced to the marks. To work this machine there is what is called a machine squad, which consists of two moulders, or three when busy, and three labourers. The pattern is placed on the plate, the labourer puts on the box, and whilst the moulder is putting in lifters or looking after parts requiring special attention, the labourer fastens the box down to the machined

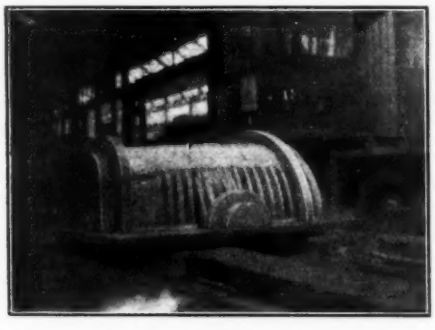


FIG. 8.—SHOWING A HALF PATTERN FOR AN ADAPTER CASTING.

plate with clips and screws. This is then put on machine, and the other labourers then fill up with sand and ram the job. By this time another job has been prepared by the moulders and is ready for the machine. This continues, and as the moulds come off the machine they are handed over

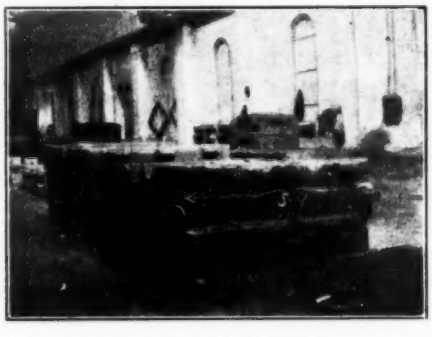


FIG. 9.—SHOWING TWO HALF-MOULDS FOR AN ADAPTER AFTER BEING RAMMED.

to the men in the shop who draw the patterns and finish the mould ready for casting. By having these various plates the machine is not kept standing, and therefore much more work can be done.

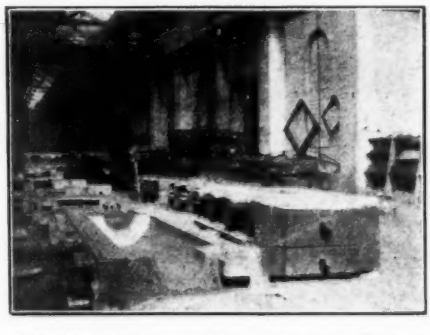


FIG. 10.—MOULDS MADE BY THE LARGE JOLT MACHINE.

The several illustrations will illustrate the above (Figs 5 to 10).

This cylinder (Fig. 11), weighing 11 tons, as cast is 36 in. dia., bore 11 ft. 6 in. deep, with head, is rammed up on the big jolt machine, the boxes are made in sections 24 in. deep, and when full of sand are just under the lifting capacity of the machine. The patterns are dowelled on to a machined plate, and the boxes are pinned to centre lines, which are also used when assembling

the job. After ramming the sections, which make up the bottom half of the cylinder to the centre line, the plate is then turned over, the same holes being used on the other side of plate. This allows for no discrepancy, and the job comes together accurately when being assembled. Before adopting this method, these cylinders were swept

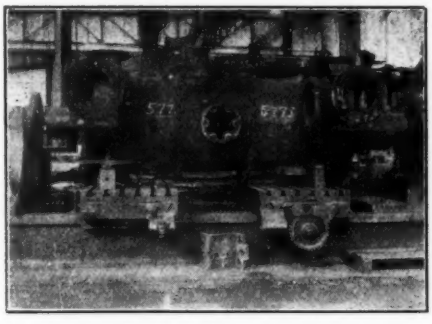


FIG. 11.—SHOWING CYLINDER CASTING.

up in loam, and the valve boxes set as the moulders bricked up the job.

It will readily be understood that it gives a much more accurate casting, and the cost is reduced very considerably. Some of the moulders do not use a rammer during the day, they draw

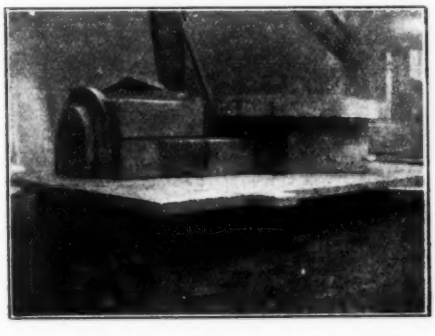


FIG. 12.—COMMENCEMENT OF MAKING A CYLINDER, SHOWING THE FIRST PIECE OF PATTERN MOUNTED ON THE PATTERN PLATE.

patterns, finish, and assemble the moulds. The moulder who has not to use the rammer becomes more adept at finishing his work, therefore doing it quicker and cleaner. Better castings are produced by the use of jolt machines, being more true

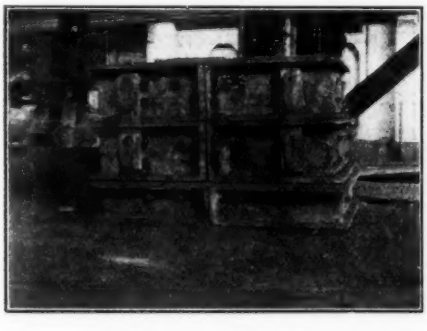


FIG. 13.—PARTIAL ASSEMBLY OF THE MOULD.

to patterns, also what is important, are less liable to scabbing, as the machine rams more uniformly than when it is done by hand, as scarcely two moulders ram alike.

The Sand Slinger.

The Broadoaks Foundry has now another machine, which is a considerable asset to its equipment, as it has installed one of the portable types of sand-slinging machines. This is proving very useful, and the method followed is to ram deep bottoms on the jolt machine, turn the job over, and put on the top part or cope, then place it under the sand slinger for ramming (Figs. 15 and 16). It is then passed to shop moulders. This denotes that very little ramming by hand is being done. Certain parts, under bars, etc., are tucked

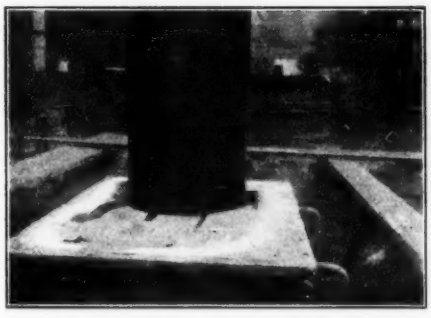


FIG. 14.—SHOWING THE MOULD IN THE PIT, WITH THE CORES IN POSITION READY FOR THE TOP PART.

by hand. The pleasing part is, no special rigs are required, being handled by the slinger in the same way as if rammed by hand.

This machine can be taken anywhere in the shop, to the bigger jobs, and is proving very

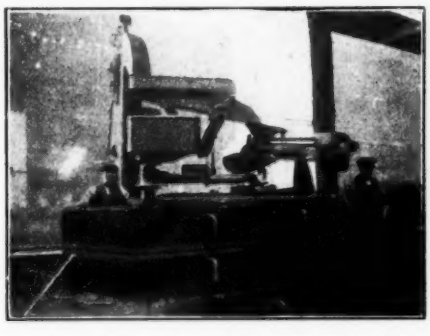


FIG. 15.—SHOWING THE SAND SLINGER AT WORK.

useful indeed (Figs. 17, 18, 19 and 20). The bedframes shown in Fig. 21 are a fairly big job, and they are made in various sizes, up to 19 tons. The one shown is about 15 tons, its length being about

FIG. 16.—THE SAND SLINGER MOUNTED ON A MOULD.

18 ft., varying according to the stroke of the engine. It is about 7 ft. wide, and 5 ft. deep. After the pattern is on its bed, and the ramming underneath is finished, it is usual to bring the sand slinger on the job, and practically the whole of its sides, inside drawbacks, and top-parts are rammed by the machine, which is moved from one part to another as required. A considerable saving in

time is effected on a big job like this. When ramming the top parts, which are over 20 ft. long, work is commenced at the end of job, then after

FIG. 17.—SHOWING THE SAND SLINGER LIFTED UP TO RAM A LARGE BOX PART.

the first 8 ft. is rammed the machine is moved along, standing on the part that has already been rammed.

This machine will also ram big cores equally well. In making a large speed-ring, for a hydro-electrical job, where the middle portion was

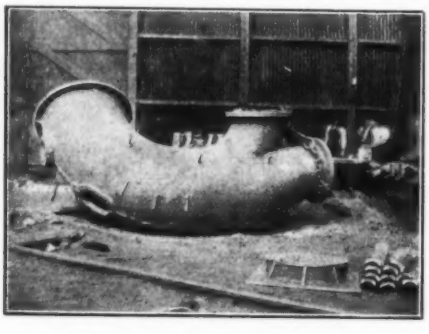


FIG. 18.—LARGE PIPE CASTING TAPERING FROM 42 IN. DIA. TO 24 IN., RAMMED ENTIRELY BY THE SAND SLINGER.

formed with heavy cores, the first set of cores was made in two weeks by four men ramming with hand. The sand slinger was then used for the 2nd and 3rd castings, and reduced the time just by one week, making a saving of 50 per cent. on the time. It has not been possible to get an illustration of this job, but the cores were 5 ft. deep in the deepest part, the diameter of the job 18 ft. 6 in., and weighed 28 tons. This machine

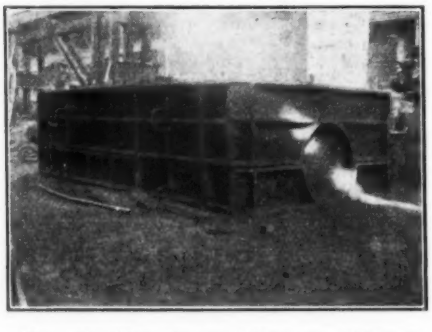


FIG. 19.—BOX PARTS USED FOR MAKING PIPES. EACH PART IS 15 FT. × 8 FT. × 2 FT. 8 IN.

is doing very well, and gives very little trouble mechanically. The blades require to be renewed fairly frequently some days, other times they last three or four days without changing. Changing a blade can be accomplished in three or four minutes. At the Broadoaks works, these blades are cast in a chill mould. They are then annealed, and providing no pieces of scrap are put through the machine they give good service, and cost very little. The top cover is also cast on a chill. This gives a nice level surface each time, enabling the blade to be set very close to it, which is necessary

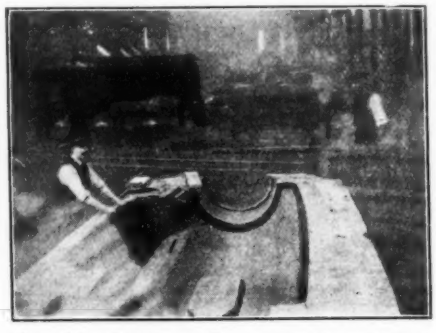


FIG. 20.—SHOWING HALF OF A BIG. TRUNK GUIDE MOULD MADE IN THE SAME BOX AS THE PIPE BY THE SAND SLINGER.

and important for hard ramming. The cover lasts about four or five weeks.

Shake-out Table.

Another useful tool, which is of considerable interest is the shake-out table. This machine con-

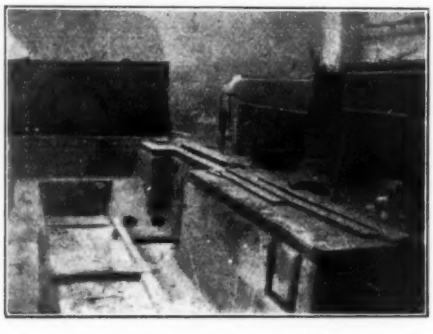


FIG. 21.—SHOWING BEDPLATE MOULD WITH CORES AND DRAWBACKS LIFTED OUT. IT HAS BEEN RAMMED BY THE SAND SLINGER AFTER MAKING THE UNDERSIDE OF THE PATTERN BY HAND.

sists of a table with a cylinder and piston at one end, the other end works in a knuckle joint. On this table the boxes are placed, after casting, for knocking out the sand ready for use again. They are picked up by the crane, shaken out on the table, then placed over the pattern again. This

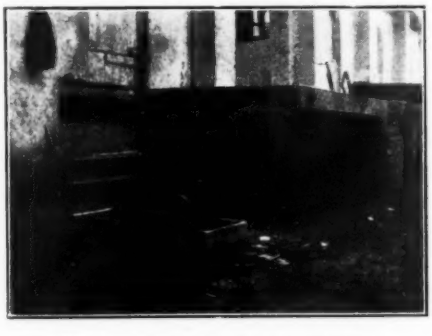


FIG. 22.—THE SHAKE-OUT TABLE.

machine saves a considerable amount of time and heavy labour. Foundrymen are aware of what it means to knock out deep top parts, which have been dried with lifters in. By the side of this table are big hoppers with mechanical riddles over the top. The sand which has been shaken out is watered and passed through the mechanical riddles, which mixes it. The hoppers are then picked up and dumped into the bigger boxes and filled by hand into the small ones.

Metallurgical Coke.*

By A. Jackson.

The first coke manufacturers followed the methods of the old charcoal-burners—that is to say, coal was first carbonised in large open piles or heaps. Air was allowed free access during the early stage of the process, and gradually cut off by blocking up the airholes with breeze as the carbonisation provided. These heaps were rectangular in shape, and sometimes attained a length of 200 ft. To build up the heap a line was first stretched in the direction of the axis, and large pieces of coal placed on either side of it. Other large pieces are placed so that, by coming together at the top, they form a triangular gallery running the whole length of the heap. The heap would then be built up with smaller coal until it attained a width of about 5 ft. at either side of the central channel. In order to light the heap stakes were placed at regular intervals, running from the top of the heap into the central channel. This left a series of chimneys, into which burning coal was introduced, so that the pile is fired at many points at the same time; ignition becomes general, and coking commences through its whole extent. The man in charge has now to prevent the action from going too far, and as soon as he observes that thick smoke and flames have ceased to be evolved in any part—in other words, as soon as he sees that the volatile matter has been driven off—he prevents the entrance of air at that point by covering it with a coating of breeze. After complete carbonisation, the heap would be allowed to cool for several days, the coke then withdrawn and quenched with water. This method was obviously wasteful; not only were the by-products lost, but some of the coal was burnt to ash, and ultimately the process gave way to beehive coking.

Beehive Coking.

The cavity of the beehive oven, which is about 9 ft. in diameter and 3 ft. 6 in. high, is internally lined with firebricks, well-jointed in refractory clay. The form resembles that of a beehive, hence its name. At the top of the dome is a circular aperture or chimney, which can be closed by means of an iron plate. A slightly arched doorway about 2½ ft. square is also left for the purpose of charging the oven and withdrawing the coke. This opening is strengthened by a heavy cast-iron frame. An oven of this type would take a charge of about 3 tons of coal, which is either introduced through the door as stated, or, in some cases, through a hole in the top of the oven. The oven is charged whilst hot, that is to say, immediately after the withdrawal of the previous charge, so that the coal immediately begins to give off its volatile matter, which escapes through an aperture in the dome. After charging, the door is closed by means of firebricks loosely piled, so that a limited amount of air enters the oven. This ignites the gases, and the temperature of the oven and contents rapidly rise. After about three hours the air supply is gradually cut off. In about forty-eight hours from the time of charging, the coking period will be over, and the oven cooled down sufficiently for drawing. For this purpose, a large iron shovel is used, suspended by a piece of chain from a crane, and this allows the workman to handle large quantities with comparative ease. The coke is thinly distributed on the floor, quenched, and wheeled away in iron barrows. In some cases the coke is quenched inside the oven by means of spraying water under pressure. Care must be taken not to reduce the temperature of the oven so much that it cannot ignite the succeeding charge.

Quenching and Sulphur Content.

This method of quenching is said to reduce the sulphur content of the coke, the decomposition of the water carrying off some of the sulphur as sulphuretted hydrogen. It is also claimed that, as the water is immediately converted into vapour, it has no bad effect upon the open walls. The quenching of coke in a non-oxidising atmosphere has the effect of producing a brighter coke, more silvery in appearance. In the beehive coking, carbonisation proceeds from the top downwards—the thicker the charge the longer the coking period—so that, by regulating the depth of the charge, the coking period may also be regulated. Coke made on a small charge, known in America as twenty-four-hour coke, contains a higher percentage of ash, by reason of the fact that the carbon at the top will be burnt away. Also, the bottom will be spongy, and will retain some of its volatile matter because of the relative low temperature at the bottom of the oven. The demand, therefore, so far as Beehive coke is concerned, is for a material made on a deeper charge. In such coke the percentage of tops and bottoms is not unduly high, and forty-eight- to seventy-two-hour coke will fetch a higher price for foundry work. From what has been said it will be seen that the fracture of Beehive coke depends on the depth of the charge; the pieces may be as long as the charge is deep. In by-product coke, where carbonisation takes place from the sides, forming a pipe in the centre of the coke mass, the maximum size of coke must be less than half the width of the oven. The Beehive ovens were also wasteful by reason of the loss of the valuable by-products, and, as far as Europe is concerned, have almost become extinct. In America, where the by-product ovens were introduced later than in Europe, the Beehive ovens lingered on for some time, but are now rapidly giving way to the modern method. So that, although the by-product oven was not introduced into America until 1892, during the year 1913 some twelve million tons, or a quarter of the total supply of metallurgical coke for that year, was produced in by-product ovens.

Coking Coal.

Good quality metallurgical coke calls for a special type of coal. Coking coal belongs to the bituminous or semi-bituminous variety. Gruner's classification of coals is based upon their coking properties. The volatile contents of coal is not an infallible guide as to its coking properties. S. Wales coal, with volatile matter as low as 15 per cent., yields a good coke, whilst other coals having a content of 40 per cent. will not coke at all. The position, therefore, so far as the volatile matter of coal is concerned, is qualitative rather than quantitative, and is attendant upon the nature of the volatile matter. Until recently very little was known as to the cause of coking properties in coal. Stokes and Wheeler, in their monograph on the constitution of coal (1918), have collected the available data, and have themselves made original contributions to a solution of this problem, and it would now appear definitely that the coking properties are due to certain resinous constituents of coal. These resinous constituents undergo a period of incipient fusion, or softening, and act as a binding agent, so that the fragments coalesce and yield a compact coke. The presence or absence of these resinous compounds, therefore, determine whether the coal is coking or non-coking, and determine the strength, hardness, and density of the resultant coke. Coal is a most intractable substance in the laboratory. It is insoluble, and resists many re-agents, and except by the process of destructive distillation does not readily lend itself to examination. However, by the aid of certain solvents it has been possible to separate the resinous compounds from the coal, and it has been proved conclusively that coking coals, after treatment with these solvents, either would not yield coke, or yielded coke of very indifferent quality. For some purposes, it would be possible to classify the

* Extract from a Paper read before West Riding of Yorkshire Branch of the Institute of British Foundrymen, Mr. H. Summersgill presiding. The author is chief chemist to the Low Moor Ironworks.

volatile matter of coal under two general headings, viz., humus and resinous. Probably a number of bodies, varying little in composition, whose exact composition, indeed, is probably unknown, would be placed under each heading. All would contain carbon, hydrogen, and oxygen, the humus bodies having the higher oxygen content. That is why in two coals of almost identical composition one will coke and the other will not. It has been stated that the resinous bodies produce coke owing to the fact that they leave behind a pitch which binds the coke. The humus bodies will not coke owing to their low pitch-forming nature. If the humus bodies are in excess, it gives a non-coking coal: if the resinous bodies predominate, it gives a coking coal. The humus bodies contain a heat value below the average; if, therefore, the heat value of a coal as ascertained by the calorimeter falls below the calculated value, as calculated from, say, Dulong's formulæ, it is certain that the humus bodies contain a greater percentage of oxygen. This is shown by the analysis of the three following coals, figures calculated out upon an ash and moisture free basis:—

TABLE I.—*Composition and Coking Properties of Coal.*

	No. 1. Non-Coking	No. 2. Semi-Coking.	No. 3. Coking.
Carbon	82.65	83.16	85.41
H.	5.55	5.18	5.36
O.	10.10	8.98	7.22

The coking properties of these coals as shown by the sand test were in the following ratios:—No. 1, 3.9; No. 2, 4.4; and No. 3, 13.5 per cent.

The relationship of the oxygen to hydrogen was as follows:—

	No. 1.	No. 2.	No. 3
Oxygen	10.10	8.98	7.22
Hydrogen	5.55	5.48	5.36
Excess oxygen ...	4.55	3.50	1.86

It will be seen, therefore, that as the excess oxygen increases the coking properties fall, because the humus bodies get more and more in excess. The same result occurs if for any reason coal takes up oxygen from the atmosphere. During a recent coal strike, when it became necessary to use up stocks which had been weathered for long periods, it was noticed that the coking power of the coal had been seriously impaired. Ash is another important factor in selecting a coal for coking purposes.

Ash and Sulphur Content.

Professor Kendall, during a discussion at the British Association, pointed out that there are three sources of ash in coal:—(1) The mineral constituents of the plant forming the coal; (2) detrital matter blown or washed into the deposit; (3) later infiltered veins. The whole of the ash in the coal carbonised remains in the coke, so that in order to keep the ash content of coke below 10 per cent., and assuming a coke yield of 70 per cent., the ash in the coal must not exceed 7 per cent. The whole of the phosphorus remains in the ash, so that the quantity is not reduced during carbonisation. A certain amount of sulphur is lost during the carbonisation process, passing off with the gas in the form of sulphuretted hydrogen, carbon bisulphide, etc. The distribution of sulphur during carbonisation was compiled by Short in 1907, working on a Durham coking coal having a sulphur content of 0.824 per cent. The results showed a loss in sulphur, so far as coke is concerned, of about 27 per cent, which, though it may not be strictly true for all coals, it is in line with personal experience. Working on a washed "Better Bed" coal with about 0.45 per cent. sulphur, and coke yield of 70 per cent., the coke will show a slightly higher percentage of sulphur than the original coal, say 0.50 per cent.

Coal Washing.

Coal is washed before coking in order to reduce the shale and dirt present, and this enables fine coal, too small for hand picking to be used. Coal washeries are based upon the principle that bodies of different specific gravities attain different velocities in falling through any media—in this case, in falling through water; the specific gravity of the coal being about 1.3 and that of the shale about 2.3. The impurities, therefore, sink first, and thus we get two layers, one of dirt, the top layer of pure coal. This top layer is carried away by the flow of water, and afterwards stamped and caked. It has been proved repeatedly that by crushing coal finely a far superior coke can be produced than by charging the same coal uncrushed.

By-product Ovens.

The distinguishing features of the by-product oven are, primarily, the recovery of the products of distillation, and, secondly, the external heating of the coal, the gaseous products being drawn out of the oven into flues, where they receive the air necessary for combustion, and thus produce the heat necessary for the carbonisation process. This, of course, increases the yield of coke because none of the coal in the oven is burnt to ash as in the older methods.

In 1861 Coppée produced an oven which was heated externally, and from which all air was excluded. In 1856 Knab and Carves produced apparatus for the recovery of tar and ammonia. These were first operated in France, and later introduced into England by Simon. There are many makes of ovens on the market, but most of them follow to some extent the original oven of Coppée and the Simon Carves oven. These ovens may be divided broadly into two classes, viz., the waste heat and the regenerative oven. In the former cold air is used for combustion. The air supply is obtained by means of the chimney draft being drawn into the flues from the atmosphere. In the regenerative oven the air is heated before combustion; the waste gases, after combustion being used to heat chequered brickwork placed beneath the ovens. The hot gases formed in the flues heat up the chequered brickwork to their own temperature, so that the hot products of combustion are reduced from about 1,150 deg. C. to 300 deg. C. before they pass into the chimney. An arrangement is provided whereby the fresh incoming air is conducted through the hot regenerator chamber before being used for combustion whilst the first regenerator is being reheated by the waste gases. This process is reversed every half-hour. In the waste heat ovens 85 to 100 per cent. of the gas produced is necessary to heat the ovens. This waste gas is, of course, incombustible, but contains considerable heat, and may be put to some use if used immediately and in the vicinity of its origin. It cannot be stored, and loses its heat quickly. Regenerative ovens only require about 50 per cent. of the available gas for heating the ovens, the other 50 per cent. remains for other purposes. It is combustible, can be conveyed any distance, and can be stored without deterioration. In Durham much of the coal is charged into the top of the oven. The coal comes from the washer, and is allowed to drain several days after crushing, and finally enters the oven with from 4 to 6 per cent. moisture. In Yorkshire the coal is compressed into a cake, and pushed into the oven through the door usually by means of a combined coal-compressing and charging machine.

This machine carries a box fitted with a movable side and a movable bottom of the same size and shape as the interior of the oven. The washed and crushed coal is dropped into this box layer by layer. It is then firmly compressed by means of an automatic stamper, which travels backwards and forwards throughout the entire length of the box. In order to cake properly, the coal should contain about 10 per cent. moisture. When made, the cake is conveyed on the machine opposite the oven to be charged, the oven door drawn up and the cake pushed into the oven by means of a ram. This ram also serves for discharging the ovens, pushing out the coke on to benches situated at the opposite side of the battery. With uncompressed coal the average carbonising capacity is 6 tons per oven per 26 or 28 hours, and with compressed coal from 35 to 37 hours, for about 10 tons of coal. In order to facilitate the discharge of the coke, the ovens are built with a slight taper, being usually about half an inch wider at the discharging or coke bench side than at the charging side. After pushing, the coke is quenched by means of a quenching hood.

Physical Tests of Coke.

The chief characteristics demanded from metallurgical coke are:—(1) Sufficient strength to withstand the burden in furnace or cupola and to withstand crushing strain; (2) a certain degree of hardness to allow of handing without undergoing fragmentation; (3) a certain degree of porosity in order that the coke will expose a maximum surface to the gases in the furnace; (4) an ash content not exceeding 10 per cent.; and (5) sulphur and phosphorus not to exceed 1.0 and 0.05 per cent. respectively.

It is to be regretted that physical tests for coke have not been standardised, although to some extent the methods employed are general. The apparatus used varies considerably.

Coke for cupola and crucible purposes calls for physical properties varying in degree from blast-furnace cokes, and we suggest that a useful line of inquiry might be made in this direction. But in order to find out the ideal hardness, porosity, etc., required in cupola and crucible coke it would appear to be necessary to first standardise the methods of making the physical tests.

The Heat Treatment of Steel.

In the course of an interesting lecture on the above subject to the Sheffield Trades Technical Societies, Professor C. H. Desch, the Dean of the Faculty of Metallurgy, stated steel consisted of iron with certain impurities. Perfectly pure iron was a soft metal, quite as soft as copper and only made on a very small scale. Pure iron was not appreciably affected by heat treatment, and unlike steel its properties were not changed by this process. The modern view of steel was that it consisted essentially of iron with the addition of a little carbon.

Use of the Microscope.

The nature of steel had been revealed in modern times by the use of two methods which had been adopted in the laboratories and generally in the works. One was the accurate measurement of temperatures, and the other the use of the microscope.

The accurate measurement of temperatures was obtained by means of pyrometers. When heat was consistently applied to steel, the change of temperature was not always regular. The accurate measurement of such changes enabled one to obtain much useful information of what happened during the heating of the steel.

The use of the microscope enabled one to see what changes took place in the steel during heat treatment. The structure of the steel when first observed under the microscope was rather puzzling, and much experience was required in order to determine accurately what changes had taken place.

In cast iron there was a good deal of carbon present, much of it in the form of graphite, which was a necessary constituent of grey cast iron. This was not the case, however, with steel, for toolmakers realised the trouble which the presence of free graphite caused in their steels. The chemical combination of the two constituents, iron and carbon, formed the alloy known as steel, and the many different combinations produced the varying properties which were found in steel.

Pyrometers.

By the aid of a number of lantern slides Dr. Desch then explained the differences between various steels as revealed by the microscope, and indicated the structure of these steels and their properties. The equipment for the modern toolmaker was not overlooked, and slides were shown of suitable furnaces, some of which were capable of automatic temperature control by a suitable arrangement with reliable pyrometers. The control of furnace temperatures became almost a necessity when the toolmaker was called upon to deal with a wide variety of alloy steels demanding accurate and different heat treatments. The eye which had been trained in the hardening and heat treatment of carbon steels frequently failed when alloy steels were being used. Cutlery steels and all carbon steels should be hardened at a temperature between 700 and 800 deg. C., and such temperature was judged by a skilled man with great accuracy. When a new steel was introduced, such as the stainless steel for cutlery and other purposes, which required hardening at a much higher temperature, the skilled man who could judge the exact temperature for carbon steels, although he knew stainless steel required a much higher temperature, was apt to harden it at too low a temperature. In such cases furnaces equipped with pyrometers were a valuable aid to the skilled men.

It was essential to check and control pyrometers, because a pyrometer which was reading incorrectly was a great deal worse than no pyrometer at all. The best pyrometers may, after a time, read incorrectly and blind confidence should not be placed in them. A skilled man who used a pyrometer with intelligence would suspect when the pyrometer was going wrong.

Discussion.

MR. E. THORNTON, who presided, thanked Professor Desch for his lecture, and asked if the use of the gas furnace was injurious to steel as used in the Sheffield tool trade.

Another member raised the same difficulty, and pointed out that he had to discard the use of the gas furnace in some cases. He found that he did not get the same results with gas as he formerly did with coal or coke, and he was anxious to know the reason why.

MR. ROBINS and other members asked questions regarding the differences in temperatures of the gas furnace, and which position in the furnace should be the correct one for the pyrometer.

In reply, PROFESSOR DESCH said that these questions regarding the use of the gas furnace were very important. Unfortunately, a good many gas furnaces were not well designed for the purpose of preventing decarburisation. There was an excess of air in the furnace which acted upon the surface of the steel and caused surface decarburisation. It was possible to have gas furnaces with the gases under proper and efficient control so that no such injurious atmospheres were present. Many firms had taken such care in the control of their furnaces, and had achieved much success with the use of the gas furnace. With regard to the position of the pyrometer in the furnace, this should be so placed to give the temperature not of the furnace away from the steel, but as close to the steel as possible. The ideal position would be in contact with the steel.

Cobalt-Plating.*

By A. LEVASSEUR, Military and Naval Engineer.

This Paper gave interesting practical information regarding the electrolytic deposit of cobalt instead of nickel upon castings, for purposes of protection. The bath used in the process contained double sulphate of cobalt and ammonium, 100 grammes, with sufficient water to make it up to 1 litre. This corresponded to the customary nickel-plating bath. But the double sulphate of cobalt and ammonium being more soluble than the corresponding nickel salt, a solution of double strength, *i.e.*, 200 grammes per litre, could be used.

The great advantage of cobalt-plating was its much greater rapidity, which was the result of the diminished tendency to exfoliate due to the greater hardness of the cobalt. With the bath mentioned the speed was four times as rapid as in nickel-plating. With the following bath:—Anhydrous sulphate of cobalt, 312 grammes; sodium chloride, 19.6 grammes; boric acid, to saturation; and water, 1 litre, speeds fifteen times greater were attained. With a current density of 10 amps. per dm^2, the result obtained in three minutes was equal to that obtained in one hour in nickel-plating, but the density of the current could be increased even up to 16 amps.

The only drawback was that the cobalt deposit tarnished, and cost a little more than nickel, but it was more resistant and consequently less thickness was required.

* Abstract of a Paper read before the Franco-Belgian Liege Congress.

Ingot Moulds.

By J. E. P.

In consequence of the very low selling price of ingot moulds, it becomes increasingly difficult for founders to produce these articles at a remunerative figure.

Most users of ingot moulds expect to buy these at between 6s. and 7s. per cwt. delivered, and insist that they shall be cast with all hematite pig-iron, with a sulphur and phosphorus content not above 0.07 per cent.

When asked why these should be cast with all hematite pig-iron, most users say that ingot moulds cast with this iron will stand the heat better than any other iron, thus giving longer life to the moulds.

It is thought by some foundrymen that there are other mixtures of iron which will stand up to the work much better, although the scrap from the ingot moulds cast with this mixture would not be so suitable for steel making.

The method of making ingot moulds differs somewhat in various localities, even the best method is not attractive in so far as profit-making is concerned.

One firm tried to make ingot moulds—each mould weighing about 30 cwt.—on a jolt ram, turn-over and pattern-drawing machine. Half pattern was fixed on to a plate, the moulding boxes were all machined where necessary and interchangeable and very expensive. Cores were made in halves, dried and bolted together. After the moulds were cored up, securely bolted or clamped, they were turned up on end and lowered into the casting pit.

This method was an utter failure after costing a good round sum, and the moulding boxes were of no use for any other job.

Another method of making ingot moulds is by moulding vertically on a jolting machine, but such a machine is very expensive, and will take a long time to pay for it by ingot-mould making, to say nothing of profit.

Fig. 1 shows the rig-up. First a base plate, AA, to which the core-barrel B is bolted, then ordinary moulding boxes, made as light as possible to lessen the weight on the machine. The pattern having been blocked in the core box is separated.

The pattern, having been placed upon a strong board and the moulding box lowered over it, the sand is shovelled in and the jolting is started until it is sufficiently rammed.

The core is made in a similar manner. The barrel B is bolted on to the base plate A, one layer of straw or wood rope being wrapped round the barrel and wetted with a slurry wash, just sufficient being used to make the core-sand adhere, then the core box is placed centrally over this, and taken to the jolting machine; core-sand is then put in, and the whole is jolted up in the usual manner. The mould and core are then finished, blacked and dried.

When closing, the outside is located by putting chalk on the joint of the core base, lowering the outside mould over and centring by the eye—a very slipshod method to say the least. Often the castings were as much as ½-in. out of centre.

These moulds were poured with tops open, the lifting eyes or loops being held in position by placing them on a piece of iron rod supported by bricks on the mould. The dross or sullage rising while casting is skimmed off when the mould is full.

The runner cups were made in such a slovenly manner that they allowed the dirt and slag to enter the mould.

Altogether it is a very dirty and careless method and seldom a week passed without two or three wasters by lumps of sand or slag settling on the inside of the ingot mould, or by the moulding box giving way, or the metal running out at the bottom joint by weakness of clamping.

Fig. 2 shows a much safer method of moulding entirely by hand. It is much more reliable and satisfactory, although a little more costly.

The bottom box A has the core barrel bolted to it, straw or wood rope is used in the same manner as before.

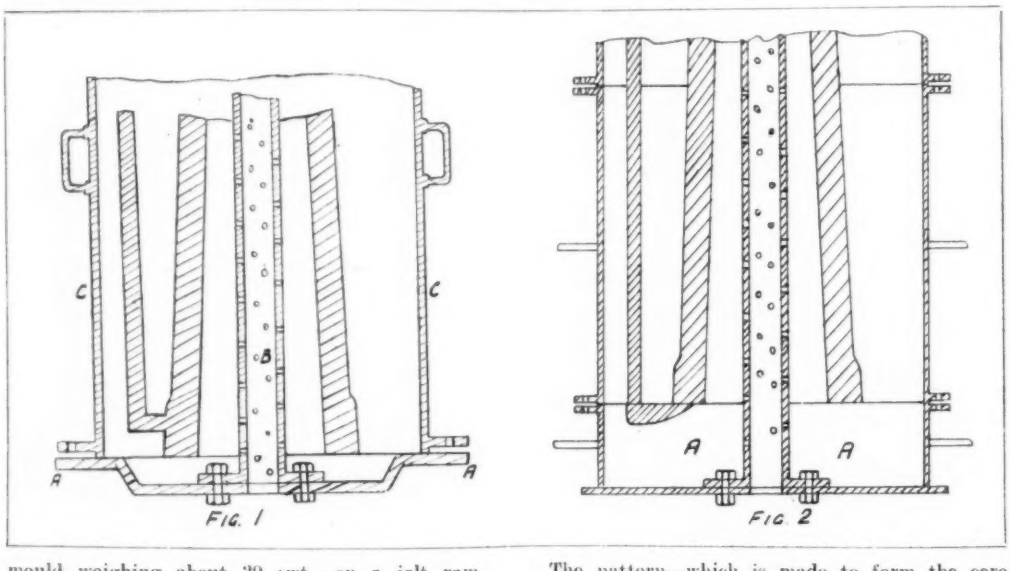


FIG. 1 FIG. 2

The pattern—which is made to form the core as well as the outside—is placed in position on the bottom joint previously made. The moulding box is put over the pattern and both the core and the mould are rammed up at the same time.

The outside mould is lifted off the pattern and then the pattern drawn off the core, both mould and core are then finished, blacked and dried. When closing, the outside mould is located perfectly by master pins.

These moulds are also cast with open tops. The runners were made so as to ensure a clean cast and let no dirt or slag enter the mould. Three hundred ingot moulds were made by these means without one waster.

All ingot moulds were numbered and records kept of the condition of metal at the time of casting, also the behaviour of the ingot moulds under working conditions.

It is remarkable how the sulphur and phosphorus varies; for instance, here are a few examples. The coke used was very low in sulphur:—

No.	Sulphur.	Phosphorus.
19	0.056 ...	0.034 per cent.
25	0.117 ...	0.042 ,, ,,
34	0.067 ...	0.023 ,, ,,

In some cases soaking pits are not used and in some instances the ingot moulds are taken out of the sand during the night and left to cool as best they can.

Soaking pits are used in some places to very great advantage. Not only giving longer life to the ingot mould, but cores can be dried in these pits, thus saving stove fuel.

The Production of Diesel Castings in Pearlitic Cast Iron.

By A. J. Richman.

(*Continued from page* 451.)

Cylinders.

These weigh from 5 to 35 cwt., and are all rammed up on the large jolt-ramming mould machine, the medium and small sizes of cylinder being rammed up in two halves at one time. These castings have three machined belts in the centre bore. The centre belts are water-cooled, the length of the central belt in the large size of cylinder being 20 in.

The cylinders are cast on the flat, with a riser off each foot and one off the opposite end where the cylinder heads fit on. The job is run on the bottom with two $\frac{3}{8}$-in. round runners; two flat down runners from the joint connecting the two

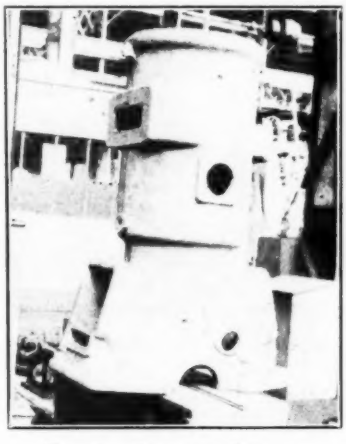


FIG. 3.—CYLINDER CASTING.

round runners. The metal enters the mould directly under the jacket core in the bottom half mould. One runner through the top part is connected to the bottom runners by means of a cross-gate cut in the joint of the top part. This is made so as to trap any dirt which might enter the runner. This method of running has proved very successful in actual practice.

The main body-core is not jointed previous to assembling the mould. The bottom-half core is lifted off the core plate, with beam and pulley chains; it is then turned over and placed into the

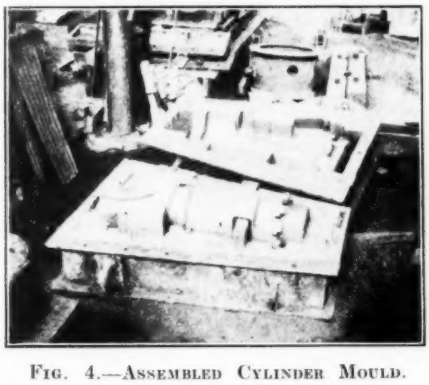


FIG. 4.—ASSEMBLED CYLINDER MOULD.

mould. The bottom-half port-cores are placed in position, and the top-half core placed on. The vent from the port cores is taken through the bottom of the job. The air from the main bore core is taken up through the top part.

For convenience in making the two ends of the cylinder secure, the top part is cut away at the back of the prints. Tubes are inserted through the top part into the vent from the main bore core, and the back of each print is rammed up securely (Fig. 3).

Cylinder Cores.

The main bore cores are made in the usual manner on a cast-iron grid. The grid is so made that the centre bar protrudes about 4 in. outside of the core at each end; this is used for lifting and turning over the cores.

The water-jacket cores are made in oil sand, and are dried and assembled on the main body core before it is dried; by this means the half-core can be blacked complete, so that when dry the assembled cores are ready for the mould. The water-jacket and the belt cores are made on cast-iron grids wherever possible. These cylinders are cast with metal at a very high temperature, and are fed in all cases at the cylinder head end. Figs. 4 and 5 show the set of cores used, the mould as it is assembled, and also the cylinder casting itself.

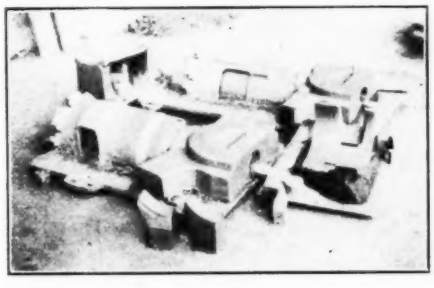


FIG. 5.—CYLINDER CORES.

Cylinder Heads.

Large cylinder-heads are rammed up on the "bumper" moulding machine, only the small types being plate-moulded. The heads weigh from $1\frac{1}{2}$ to 9 cwts., and are made to a number of different designs. In all cases the surface to stand the explosion is cast face-up, which may appear to be a risky procedure, but with proper attention to methods of gating and pouring exceptionally good results have been obtained. The difference in the cost of production between the method used and, on the other hand, of casting the explosion-face-down is very large when the large numbers made is taken into consideration. Moreover, the purely foundry risks are much greater by casting face-downwards.

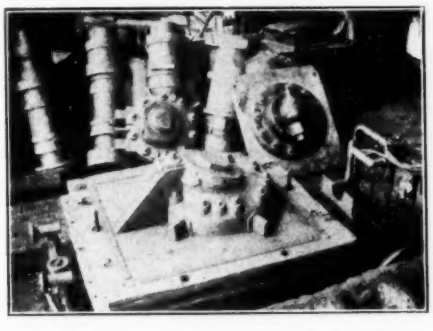


FIG. 6.—CYLINDER HEAD ON THE MOULDING MACHINE.

The method of running all cylinder-heads is based on the idea that the position of the runner is such that in the event of dirt or dross entering the mould it will be situated where it is of least importance. In all cases when deciding the best position for a runner it is always safest to assume that a certain amount of dirt will find its way into a mould, and so place the runner that it is located if possible in a position of little importance.

XUM

All cylinder-heads are run at the bottom, with as small a runner as possible consistent with filling the mould at the correct speed. The runner is placed as far as possible away from any thick sections or bosses, as often a badly placed runner is the cause of a casting leaking under the water test. These castings have been exceptionally free from shrinkage trouble and blow-holes, largely due to the use of hot metal and slow running.

When it is considered what heavy impact and high flame-temperatures these cylinder-heads have to withstand when running in the engine, the importance of this casting may be realised. The

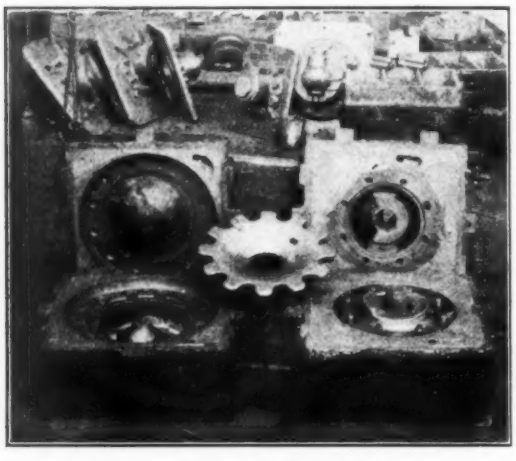


FIG. 7.—CYLINDER HEAD MOULDS.

force of the blow between the top part of the piston and the cylinder head of an engine having an 18 in. diameter is about 20 tons, occurring 350 times per minute with a very high explosion temperature.

Head Cores.

All cylinder-head cores are made in oil sand, and thin cast-iron grids are used in all except the very small sizes. In most of the water-jacket cores four round arms are provided to bring off the vent and support the core in the mould. These four points are the only places where the jacket-core cuts through the outside wall of the cylinder head. Figs. 6, 7 and 8 show the various forms of cylinder heads with their cores and the moulds as prepared for casting.

Cylinder Liners.

These liners are of two types; one is the ordinary straight liner for the four-stroke engine, and the other is for the two-stroke design having two

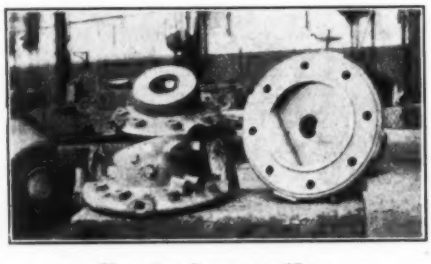


FIG. 8.—CYLINDER HEAD.

nests of ports, or a continuous row of ports all round the circumference of the liner, thus acting as inlet and exhaust ports. The latter design, with two nests of ports, constitutes the great part of the output being described, and these liners weigh from 2 to 12 cwts. each. (Figs. 9 and 10.)

The liner pattern is in halves, and is so constructed as to form the runner basin and the two top runner-inlets. The box-parts are cut away at one end to fit the runner head on the pattern. In the bottom half of the mould a bottom runner is made, the idea of which is to form a combination of top and bottom runner.

The port cores are placed in the green mould and set in position with gauge sticks, and then dried in position. The moulds are taken from the stove and closed as soon as possible, so as to keep the moulds warm. The aim is to cast the metal into the moulds while they are still at about 90 deg. C., although this temperature varies a little, but it is always between 80 and 100 deg. C.

The two top runners are plugged, and a piece of block tin is placed over the bottom down runner. When the liner is being cast the tin holds up the molten metal for a sufficient length of time to fill up the runner basin with the molten iron. Before the two top plugs are lifted a certain amount of metal is allowed to enter the mould, after which the top runners are opened.

Principle of the Runner.

When sufficient metal has entered the mould through the bottom runner as shown in the illus-

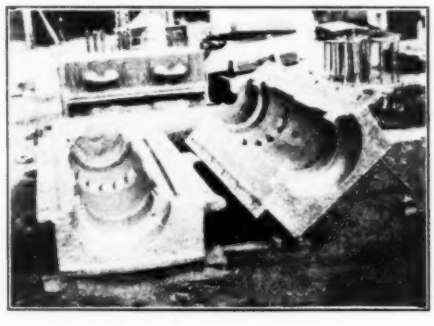


FIG. 9.—LINER MOULD.

tration (Fig. 11), the two top plugs are lifted. The two streams of metal from the top runners drop between the two rows of port cores, this having the effect of breaking up any accumulation of dross or dirt on the top of the metal already in the mould, and draws this away from under the port cores (as shown by the arrows), and so brings it up between the port cores as the mould fills, and thus up to the sullage head instead of lodging below the cores. A number of different methods were tried before this method was adopted as standard for this type of liner.

For liners with a continuous row of ports all round the circumference the same type of runner is used, but with the following difference: the bottom runner is used to fill the mould up to a level above the ports before the top runners are opened.

Trouble is sometimes experienced with the liners having two nests of ports. The ports practically cut the casting in halves, excepting the two fairly narrow partitions between the

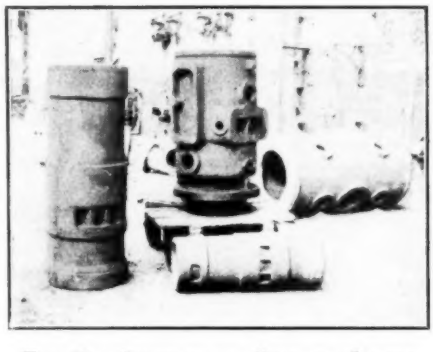


FIG. 10.—CYLINDER AND CYLINDER LINERS.

inlet and exhaust ports. In these two places, shrinkage sometimes occurs owing to the casting below the ports taking the metal to feed its liquid shrinkage from it. The design of this type of casting would naturally lead one to expect shrinkage trouble at these two points, but it has been found that the problem is a purely metallurgical one, and only evinces itself when the phosphorus content of the iron is too high or the total carbon below 3.1 per cent. It is a peculiar fact that this design of liner would be very difficult to produce in an ordinary foundry iron without resorting to denseners on account of the

shrinkage at these two points. Figs. 9, 10 and 11 show the liner mould, the finished casting and also the method of arranging the runners.

Pistons.

These may weigh from 2 to 10 cwts. each. The large sizes are moulded from a pattern made on the same lines as the liner pattern, the runner head and runners being made a part of the pattern. The method of moulding is the same as the liners, *i.e.*, made on the flat and then turned up for casting vertically.

The runner is formed so that there are two gates from the runner head, each feeding a radial runner in each half mould. From these two radial gates a succession of small inlet runners are made all round the circumference of the piston walls, except over the gudgeon-pin boss cores. This type of runner breaks up any dross or dirt floating on the top of the metal which is apt to lodge in the mould during its passage up into the sullage head. The runners are kept very small so that when pouring the job, no difficulty is experienced in keeping the runner full of metal.

The cores are made in halves on cast iron grids with a thick prod to carry the gudgeon pin core. The half cores are jointed while warm and placed straight into the mould. The gudgeon pin cores take the weight of the core while the mould is being closed, but when the mould is turned up vertically for casting the core requires to be supported. To take the upward lift when the piston is cast, a bar 2-in. square is inserted through two wrought-iron eyes, one in each half box part and through the two half core grids

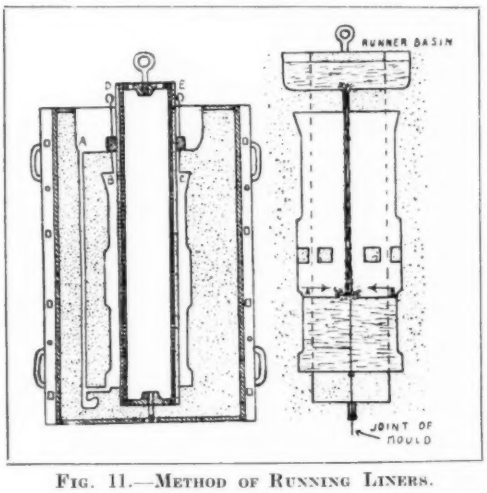


FIG. 11.—METHOD OF RUNNING LINERS.

which protrude through the end of the piston core. Wedges are placed in where required to keep the core steady.

Smaller pistons are made by a different method: the pattern is a solid one and is made to mould vertically. The core is supported and located by a wide and deep tapered print. On the underside of this print a circular runner is made with a number of small inlet-runners into the walls of the piston. To connect up the circular gate, a down runner is made through the print of the core. No top part is required by this method. A narrow plate is placed across the top of the core and cramped to the lugs of the box part to take the lift of the core when the piston is being cast.

The only difficulty occasionally experienced with pistons is a small accumulation of dross which lodges directly above the gudgeon pin core, at a point where the piston tapers down rather suddenly at the skirt. It is not possible to place runners at these two points, as the metal would drop on to the gudgeon pin core which would likely cut up badly. A well-known piston trouble which does not manifest itself in this case is shrinkage in the gudgeon-pin bosses, on account of the kind of iron being used which obviates that particular trouble.

Figs. 12 and 13 show the piston mould and cores, and also arrangement of core lift and support, and the final casting.

Mould Temperatures.

The mould used for casting the more particular items of castings made in improved cast iron are not pre-heated to any special extent other than the ordinary drying process. Moulds are closed and cast as soon as possible after leaving the drying stove. In this way the mould temperatures may vary between 80 and 100 deg. C. To take an example of a large liner weighing 12 cwts., the casting having an average thickness of

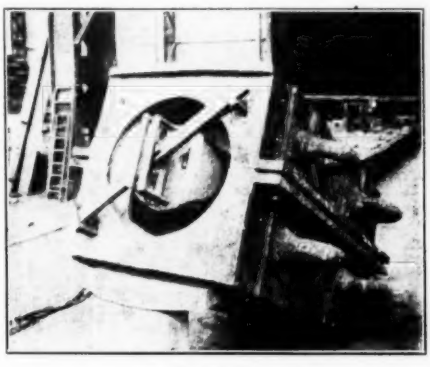


FIG. 12.—PISTON MOULD.

1½ in. of metal, the mould temperature is about 95 deg. C. No cylinder iron is cast into a perfectly cold mould, as with the character of the metal used the resulting casting would not be commercially able to be machined. Too low a mould temperature is indicated by hard metal in such places as the edge of bosses or any section of the casting which protrudes from the main body of the casting. Taking the liner casting just named, which would be made from metal having an analysis of silicon 0.97, phosphorus 0.2, manganese 0.6, and total carbon, say, 3.2 per cent., even although this casting made in the warm mould would be perfectly grey, the runners are very hard, and vary from white to mottled in fracture. The bottom runner from the runner head down to within 2 in. of the actual casting is only 1 square in. in section. This runner fracture is often taken as a quick and rough guide to the result of the previous day's mixture.

Gating.

The Ronceray method of gating is used in many of the small, highly-machined castings which have to withstand high pressures, hot fuel-oil at a pressure being the liquid which many of the castings have to withstand. This method of running has been the means of curing much

FIG. 13.—PISTON MOULD.

shrinkage trouble in small castings, such as air-valves, air-valve starting bodies, oil pump-bodies, atomiser-bodies and sleeves: in fact any casting where a perfectly solid casting is essential.

This method cuts out a great deal of rod feeding, besides giving better results than can be obtained by rod feeding. Rod feeding is often not a practical proposition when one has a large number of such jobs to cast at one time. One job in particular, of which large numbers are made is a small air starting-body. The casting consists of four bosses, two of them round and two oval, which form a small solid body. The casting is faced on each boss and bored four ways

to the centre with a valve seat in the centre of one bore. The job is moulded four in a 12-in. box part, and often a dozen boxes are cast at one time. To feed all these would not be a practical proposition.

Engine Beds.

These are made to take from one to six cylinders in the largest size, and one to four cylinders in four other sizes, *e.g.*, marine and land type. The weight of the beds may vary from 8 cwts. to 8 tons. All the sizes up to four cylinder are rammed up on the bumper moulding machines.

In all the beds the bearings are water-jacketed, and owing to this class of engine being arranged for crankcase compression, the crank-well must be air-tight. The method of running the beds is the same in all cases, but the position of the runners varies a little with the size. Up to the two cylinder size in all cases the beds are run at the fuel pump extension end. All the beds above that size are run along the side, the number of runners varying with the length of bed.

The runner inlets are placed at the bottom of the mould, and down runners from the joint connect up with these. The moulds are cored up previous to being dried. Vents can be made secure and the mould can be finished and made a much cleaner job this way than by drying the mould before coring up. The back of the beds is formed entirely of cores, and these are bolted into a top core-print which is the same size as

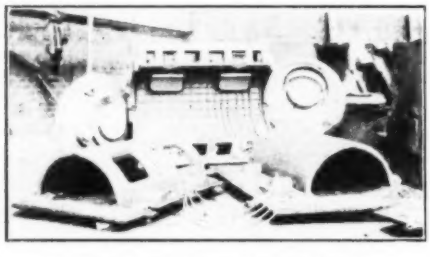


FIG. 14.—WATER JACKET CORE.

the bed-pattern. A four-cylinder bed-mould contains sixty cores in its construction, the casting itself weighing five tons.

Bed Cores.

The bed cores are all made with cast-iron grids. The bearings and water-jacketed cores are made in oil sand and the others are made in ordinary core sand.

Water-cooled Silencers.

These are of two types, cylindrical boiler form and box type. These are made in single, double and triple for all sizes of engines.

The largest size is 9 ft. long and 2 ft. 9 in. in the bore, with three tangential branch connections and a 4-in. internal flange at each end. This type is used for a 3- or a 6-cylinder marine type of engine. The job is moulded in halves on its flat, and then turned up into a vertical position for casting.

A bottom runner is used in conjunction with top runners. The top runner is cut around the print of the main bore core, with a succession of small ingates all round the bore except directly over the branch cores. The bottom runner is opened first so as to allow metal to enter the mould and act as a cushion for the metal dropping down from the top runners.

The water jacket cores are made on a built-up grid, consisting of light cast-iron segments wired up to a wrought-iron rod running the length of the core. The small sizes are made in oil sand and the large one in loam sand. The cores made in loam sand do not need bedding out; the core is turned out on a flat plate in the usual way. To avoid any chance of the core opening out with its own weight while drying, two binding wire stretchers are strained across from the tips of the cast iron grid segments previous to the core being turned over.

Assembling the Moulds.

After the mould has had one night's drying, the branch cores and the half-jacket cores are placed in position in the mould. The top half-jacket-core is wired in position at the back of each of the four core-prints. By this method the vents can be made secure, and core-prints made good. After the mould has been stoved again, the barrel-core is placed in and the mould is closed. One point which must be carefully watched when this method is used is that a "touch" is made where the top and bottom half-jacket-cores meet, as it is difficult to chip out any fins which may form at that point.

Fig. 14 shows the water-jacket core and grid, as well as the finished silencer casting.

Flywheels.

All flywheels up to 7 ft. dia. are machine-moulded from a half-pattern. The wheels are of the disc type, with a solid rim for electric type and a recessed rim for standard type. The recess in the rim is formed by cores, six of which are placed in the bottom half and six in the top. A fairly wide print on the pattern gives the core a good seating. The cores are made on a cast iron grid segment, and are placed in the mould in the green state. After the pattern is drawn from the bottom half of the mould, the barring hole cores are placed in position, and the rim finished and blacked. The cores are then placed in position, and the whole finished and blacked. Very much the same procedure is gone through with the top half of the mould. Extra machining is allowed for by using wood segments round the rim.

The wheels are run on the rim by three flat runners about 6 in. apart, so that the metal drops down into the rim of the wheel so as to miss the recess cores. The risers are taken off the rim. The recess cores in the top half-mould are held in position by hook bolts. Twelve holes through the top part are arranged round the core print. The hook bolts are hung on to the wrought iron eyes cast in the grid previous to the cores being placed into position.

After the mould is dry, the bolts are tightened up to fish plates. This method of putting the green cores into a green mould has proved to be the cheapest and cleanest manner of mould-making. Dry cores have been tried in a green mould, and dry cores in a dry mould, but both these methods are not only more expensive, but they do not produce such a clean casting.

A 4-cylinder bed casting weighing 3 tons 5 cwts. is made on the moulding machine, the dimensions being 14 ft. by 6 ft., with a lifting capacity of 12 tons. Another size of moulding machine measures 7 ft. 6 in. square, on which all flywheels up to 7 ft. diameter are made, taking up to 10 tons. Four smaller machines range from 4½ ft. square down to 3 ft. The type of plate pattern used for plate moulding is in most cases a half-pattern on each side of a wood board having jigged brass bushes in which loose pins are used.

A New Method of Strickle Moulding.*

By SAPPIN FRERES.

The authors described a new method of strickle-moulding invented by them, which obviates the pulls occurring during the stripping process when the walls of the casting are vertical or have not a sufficient taper. The method consists in subjecting, after stripping, the print formed in the upper box, previously turned 180 deg., to a strickling round a spindle; and in order that the spindle may be perfectly centred on the casting, it is arranged in a fitting sunk in the sand in the upper box at the time of filling.

To Fasten Leather or Rubber Tyres on C.1 Bogie Wheels Permanently.—Place 1 part nut galls in 8 parts water and leave to soak for a whole night. Strain well, and apply hot to the leather or tyre. Previously warm the wheel and coat same with glue mixed with a little black treacle.

* Abstract of a Paper read before the Franco-Belgian Foundry Congress.

Institute of British Foundrymen.

BIRMINGHAM, COVENTRY AND WEST MIDLANDS BRANCH.

By the courtesy of the directors of Messrs. Sterling Metals, Limited, Coventry, a firm engaged in the production of ferrous and non-ferrous motor castings, a party of members visited the works on Wednesday, November 18, and there was afterwards a meeting of the Branch at the Oddfellows' Hall, Little Park Street, Coventry. Mr. E. Player, works director of Messrs. Sterling Metals, Limited, presided at the meeting, and Mr. A. Marks spoke on the Manufacture of Special Cast Iron.

In opening the proceedings, the CHAIRMAN commented upon the inclusion of Coventry in the title of the Branch, which, in view of the state of affairs existing in Coventry during the past year, was, in his opinion, a good move. As a Branch of the Institution, Coventry thereby, at any rate, regained its identity, and the step should tend to bring the Coventry members more closely into touch with the activities of the Institution. He welcomed the action of Birmingham in arranging that meeting at Coventry, and added that he understood there would be further lectures in the district as opportunity served. Introducing the lecturer, the Chairman said Mr. Marks was a metallurgist who had made a particular study of cast iron, a material which most of them found reason frequently to curse fluently, but in which they were nevertheless deeply interested.

THE MANUFACTURE OF SPECIAL CAST IRON.

MR. MARKS said the problem of obtaining perfect castings was one which involved the co-operation not only of the metallurgist but of the foundryman. In that connection it must be remembered that the definition of a practical man was rapidly undergoing a change. It was like the old German chemist's definition of a chemist, that a chemist who was not a physicist was not a chemist at all. Perhaps it was now being realised that the metallurgist was not a metallurgist who was not a physicist. The metallurgy of cast iron and the structures of the diagrams had been worked out largely by physicists. Alluding to high-tensile cast irons, Mr. Marks said that in the case of automobile engines they did not reach such stresses or temperatures that anything very special was required. He had run air-cooled engines at red heat, though one did not do it as a regular thing. Diesel engines frequently attained red heat, so that high-tensile cast iron was mostly considered from the point of view of the Diesel engine, automobile engines not being so important from that aspect. They could have an absolutely flawless automobile cylinder any time they liked provided they were prepared to pay the price of it. He contended that owing to lack of real technical training in the people put on inspection of automobile castings, automobile cylinders were scrapped which for practical purposes were perfect. He had made automobile castings for every well-known car in the Midland area, both air-cooled and water-cooled, and he was speaking out to the automobile trade in general when he said that the inspection of automobile castings was not done on a technical basis, nor was it done on a business basis. Material which for practical purposes was perfect, was scrapped on account of technical ignorance in the inspection departments.

Cast Iron for Automobiles.

Cast iron for automobile purposes did not really demand an exceptional iron. What it demanded was an iron which could be cheaply machined and which would be sound and have a reasonable amount of wear. Cast iron which could be machined at a reasonable speed had a reasonable amount of wear, but if high wearing qualities were required it could not be expected that they could run their tools at the speeds which could be put on to common cast iron. The automobile engineer got it into his head that he must have specially good cast iron, and laid down a Brinell hardness test of 220. Then he designed his automobile cylinders with a barrel thickness of, say, $\frac{3}{8}$ in., and his outside casing 5/32 in. If he got 232 hardness on his barrel casing, by the commercial methods in use at the present moment, he would get on his water casings a white iron which would very soon crumple up. That demonstrated one of the follies of laying down a hardness specification in a job of that kind. There were many automobile engineers within fifty miles of Birmingham who were insisting upon a hardness test in the case of automobile cylinders, and blaming the foundryman if the test was not met, and scrapping them, and who yet had not the most elementary knowledge of the relation between Brinell hardness and wear. For practical purposes there was very little connection between Brinell hardness and wear. There was nothing more painful to him than to see an automobile casting sent round to the various foundries with a chemical specification on it.

Fords Cylinder Specification.

The only specification for automobile castings he had seen which was worth the paper on which it was written was one which emanated from Fords for automobile cylinders. In that case the man who wrote it evidently had some idea of what was required in the composition of cast iron. Certain schools of engineering held the view that combined carbon was a measure of wearing qualities, and they would specify a minimum combined carbon. It might be 0.6 per cent.. The combined carbon might be 1.2 in the jacket, but as low as 0.6 per cent. in the barrel, because the rate of cooling for the barrel was totally different from the outside jacket wall. It was possible to have combined carbon 0.4 or 0.3 per cent. and still have wearing qualities as good in the iron as with the combined carbon at 0.8 or 0.9. After specifying a certain hardness figure for the cast iron, the automobile engineer would put his piston into the cylinder with a set of piston rings—sometimes two, sometimes three—and he would put on those piston rings a definite pressure. He then argued that so long as he had a certain pressure on the rings, provided the pressure per square inch was not above a certain amount, his automobile would be all right. It would be all right from the point of view of the escape of gas. But at the ends the rings were narrow, and so long as they were free to oscillate slightly they would act as scrapers on the cylinder wall, so that the design of the ring on the piston was of far more importance to the wear of the iron than the question of the composition. In the case of Diesel engines they were working at higher temperatures and stresses, so that the tensile strength and resistance to heat were of the first importance. It had been found that strength at high temperatures was chiefly a question of keeping down two factors, namely, the graphite and the silicon. Ordinary 3 per cent. or 2 per cent. silicon iron would, if heated continually, decompose and give what was termed growth—that was assuming the temperatures were fairly high. Growth had been known in a super-heated steam-engine casting where the silicon was as low as 2.0 per cent., but the movement was in the right direction when they reduced the silicon. It was not usually a commercial proposition to put into an automobile engine an iron with much less than 1.6 per cent. of silicon, and a commoner figure was of the order of 2.0 per cent. That iron, if heated, would decompose, but the reduction of strength was not very important, because most of the engines were sufficiently well water-cooled to keep the temperature well below anything serious. In Diesel engines it was not possible to keep the temperatures down. One of the chief faults of the Diesel engine was that it was cooled with sea water, and therefore very soon after it left the builder's hands it began to silt up. He had frequently seen deposits taken from the cylinder head which were 8 in. thick. Where the iron was underneath such a deposit as that and was subjected to the temperature of a Diesel engine it was not likely that the iron was going to be affected by the cool water. The engines were run at a warm temperature because the knock sounded a little more gentle. No engineer would think of running a steam boiler

with his furnaces caked with a quarter or half an inch of scale. Therefore the design of the engine should be altered or the cooling should be effected by means of purer water than sea water. No foundryman or metallurgist could produce iron which would stand up to conditions of that kind, although they tried to, and got blamed for failure. The engineer ought to come to their rescue by making conditions impossible in his engine which necessitated special iron. Instead, the engineer judged cast iron on those conditions, and in some cases he resorted to steel. He had known where Diesel engines of certain types had been built with a steel cylinder head and cylinder, with the result that the foundryman had had to make five or six of the heads before he obtained a sound one, on account of the difficulty of casting in steel.

Establishing Suitable Compositions.

In trying to meet the conditions put up to them by the engineer they first of all had to get their silicon suitable. Cast iron contained six elements—relatively a small amount of iron, combined carbon or graphitic carbon, silicon, sulphur, phosphorus and manganese. The part of the diagram with which they were concerned ran from about 1.7 per cent. of carbon—the border line of the steels—up to the maximum solubility of carbon, about 4.6. An iron containing a percentage of, say, 1.7 gave a structure when it was cold showing three main things—graphite, cementite and pearlite. That took no account of the silicon, sulphur, phosphorus and manganese, and no diagram was possible. A great deal of work in connection with cast iron was based upon considerations not of the whole of the elements, but upon considerations of the influence of each element, and then the application of experience to the settling of the exact composition to use. Manganese was one of the most useful agents for giving toughness and wearing qualities. The absence of phosphorus contributed to strength: they therefore brought that down to a minimum. On the other hand, by bringing it down to a minimum the foundryman met with difficulties. Therefore, they endeavoured to run it at about 0.3 per cent. The sulphur was a function of cupola practice and the iron. The iron as delivered to them rarely contained any percentage of sulphur that it was necessary to worry about; they added to it in the cupola. The silicon was a factor they controlled, and should be about 1 per cent. Diesel castings, according to thickness, could be run at from 0.5 of silicon or even less, up to 1.4 or 1.5. For Diesel cylinder-heads they ran the silicon round about 1 per cent., and what he might term Diesel iron frequently contained about that percentage of silicon. They controlled the combined carbon and graphite by manufacturing the iron in an open-hearth furnace or cupola with suitable variations in the amount of coke and the amount of steel added to the iron. The amount of graphite present was the chief factor in strength, and consequently the amount of silicon, because the silicon decomposed the cementite when the temperature began to get up. In moulds of a complex character they had to use chills to overcome the troubles known as shrinks and draws. Shrinks were usually due to gas, and whilst chills were useful even in removing the gas they were only an indirect means of producing the result required. A mould which would be perfectly satisfactory when it did not contain a chill at all would be useless in a mould containing chills. As they approached a steel character in order to get up the strength they had a material which would chill more rapidly. Further, as they reduced the graphite the iron became more sluggish. They balanced that by putting up the phosphorus slightly. If there was a high phosphorus-content, however, they obtained a metal which was brittle. About 0.3 per cent. of phosphorus would give them a satisfactory composition. Where the mass of the metal was relatively large to the mass of the mould as it was when they were casting a large standard Diesel engine casting, the mould had no chilling effect, and they got a pearlitic iron without any special precautions.

Before showing a number of lantern slides, Mr. Marks gave the composition of two strong irons as follows:—(1) Combined carbon, 0.72; total carbon, 2.6; silicon, 1.5; sulphur, 0.08; and manganese, 0.63 per cent. (2) Combined carbon, 0.64; total carbon, 2.74; silicon, 1.1; sulphur, 0.07; and manganese, 1.1 per cent.

DISCUSSION.

Referring to the inspection of automobile cylinders, the CHAIRMAN said it broke one's heart to see perfectly usable castings thrown out because perhaps on the foot there was a little sand-hole. The relation between hardness and wear was a very much debated subject upon which there seemed to be no agreement whatever. There was also a variation of opinion with reference to machining speeds. He regarded the Paper as quite one of the most interesting that they had heard.

In proposing a vote of thanks to Mr. Marks, MR. A. HARLEY alluded to the relation of hardness and wear, remarking that it was not only a matter as to which there was a great deal of difference of opinion, but a great deal of ignorance. He wondered if Mr. Marks had noted whether ordinary 20 per cent. semi-steel was more subject to wear than ordinary close-grained cylinder iron. Machine speed was a very important factor in automobile work. The engineer wanted to machine his castings at good machining speed, and they had to compromise to some extent in that matter. He sympathised with the remarks that had been made on the subject of the scrapping of good cylinders.

MR. D. WILKINSON said there was no questioning the fact that very serious losses occurred to the community at large through the super-inspection of automobile cylinders. He thought the average inspector ought to rid his mind of the idea that it was his duty to throw material away. At the same time, it was possible that the existing super-inspection had had the effect of making the foundryman much more capable and careful. As regarded Diesel engine castings, the only experience he had had was in the making of steel heads, and he could not agree with Mr. Marks' views regarding those of steel heads. About a couple of years before the war the foundry with which he was then connected received a blue print from a firm in a neighbouring town which used a Diesel engine. They explained that they had had continual trouble with the cylinder head, and wanted to know if a steel one could be made. His firm undertook the task, and made four. They were about 8 cwts. each; all the four were good, and they answered very successfully. They certainly had a fair number of chills in them, but the way they overcame the trouble which they anticipated, which was that definite cracks would develop in the thin dividing sections, was by heating the mould to the highest possible temperature. Then, during the war, at another steel foundry, they did quite a number of heads, but for a smaller type of oil engine, weighing about 3 cwts. They made eighteen or twenty, and out of the lot only one was defective, and they were said to function in a perfectly satisfactory manner. He had on more than one occasion expressed the opinion that if some of the more intricate and difficult Diesel engine castings where the parts were not subject to wear were made in steel, the Diesel engine might be more reliable than it was to-day. The tendency in Diesel-engine-castings, with the low carbon they had, was to approach a steel character. Personally, he had never been able to get down to 2.8 per cent. carbon in any cupola-made metal. He would like to know whether the figure quoted by Mr. Marks was a laboratory figure or an actual practical figure.

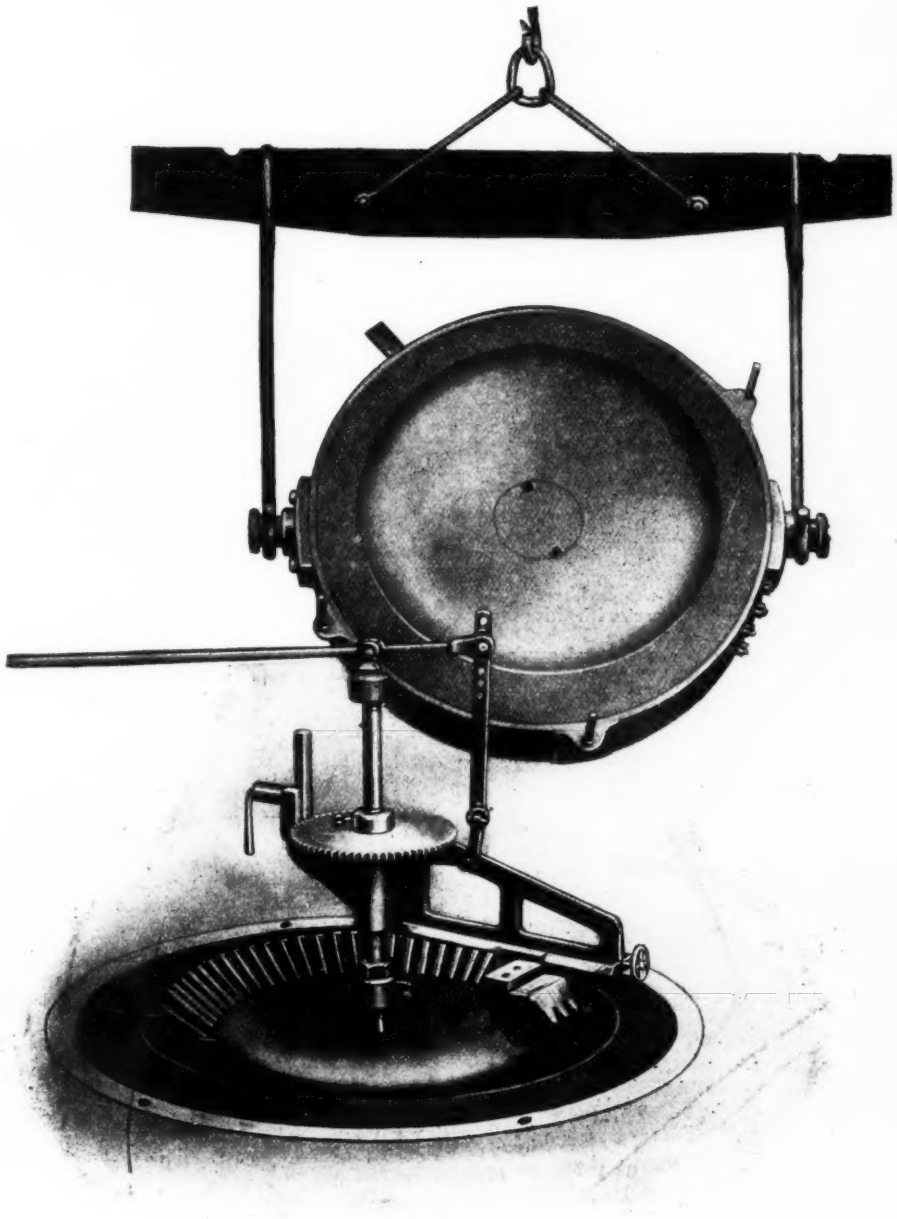
The vote of thanks was heartily accorded.

Replying to some of the points raised in the discussion, MR. MARKS said there was a sample of pig-iron on the table which had been produced in the blast furnace. Mr. Wilkinson could have a sample and analyse it, and so satisfy himself that even in the blast furnace it was possible to produce as low total carbon as 2.8.

On the proposition of Mr. D. H. Wood, seconded by Mr. Starr, the Chairman was warmly thanked for presiding.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

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LANCASHIRE BRANCH—JUNIOR SECTION.

At the Manchester College of Technology on Saturday, November 21, with Mr. R. Stubbs presiding, Mr. R. Yeoman of Stockport, the first John Wilkinson medallist, read a Paper on "An Elementary Study of Foundry Sands." The author outlined the origin and disposition of sands, uses of sands, analysis and physical tests. The tests described were the outcome of the author's own personal experiments. His quest was for simple but reliable tests which could be applied in the foundry. The necessity for standardising such tests was emphasised, and the importance of eliminating the personal factor was stressed. The results given were confined to red moulding sands, but a very large amount of information was gained from the carefully tabulated figures.

In opening the discussion MR. T. MAKEMSON congratulated the author upon his Paper and on the way in which he had presented it. He had clearly shown the value of the tests which he had applied. MR. YEOMAN had mentioned analysis, he agreed with him that for most purposes the tests he had indicated were of more practical use than an analysis. The chief point was that by testing scientifically one could often use local supplies and thus save costly freight.

MR. J. MASTERS (the President of the Lancashire Branch) recounted a recent experience on a newly opened quarry. He emphasised the fact that the natural bedding of sands gave distinct layers with characteristic properties. Near the surface one obtained sharp sand admirably suited to oil-sand core-production. Sixteen feet down the face a layer of the best medium red sand was obtained. He congratulated the lecturer and hoped he would proceed further with his very useful study.

MR. C. F. BRERETON said the natural sands of this country were excellent and required little milling to render them suitable for moulding purposes. For this reason little systematic research had been engendered in this country. In America synthetic sands were more or less essential, and as a result a large amount of research had resulted. With regard to analysis, in these days when metals were employed with high melting points and high degrees of superheat, it was essential to know the analysis. This applied more especially to sand for steel castings. As regards sieves, those with punched holes gave more consistent and reliable results than did wire mesh sieves. If no microscope was available a good magnifying glass would give very useful information as to grain shape. The author was just at the beginning of a useful study and it was to be hoped that he would continue and perhaps give his further results at some future date.

A vote of thanks was proposed by MR. BEAN, who thought that the author must really have his subject at heart to have spent his leisure in the summer in testing sands. The members appreciated that and hoped Mr. Yeoman would continue.

The announcement was made that the next lecture would be given by MR. J. S. G. PRIMROSE on "Physical Testing of Foundry Products."

Shrinkage and Blow-holes.*

By J. LÉONARD, Mining Engineer.

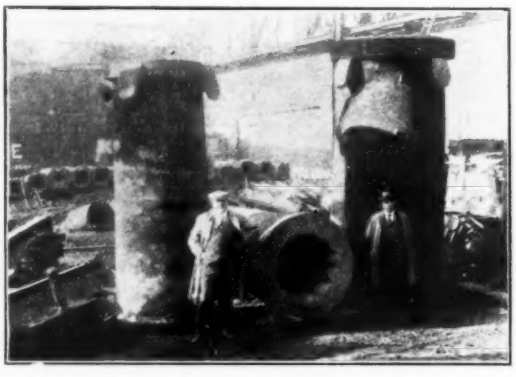
Referring to a previous Paper on "Comparative Foundry Work" (de Fleury), the author said that it was difficult for him to speak of defects in castings without having previously defined what was meant by defects. What was called "the Léonard effect" certainly existed. This was a kind of pipe or funnel caused by the gases seeking to escape by the path of least resistance. Several examples were given of castings in which this defect readily occurs.

MESSRS. E. WHITEHEAD and W. BAKER, foundry materials merchants, 45, Green Lane, Oldham, trading under the style of Edward Whitehead & Company, have dissolved partnership.

* Abstract of a Paper read before the Franco-Belgian Foundry Congress.

South Wales Makes Ingot Moulds for Canada.

Messrs. Baldwins, Limited, at the new foundry attached to their Landore Works, Swansea, have cast as one of their first castings four exceptionally large ingot moulds with fluted cores. The two larger ones are said to be the largest castings ever made in South Wales. They each weigh 32 tons, and stand 12 ft. high. The diameter



TWO LARGE INGOT MOULDS MADE TO A CANADIAN ORDER.

is 5 ft. 9½ in., tapering to 4 ft. 8½ in. The smaller pair, which are illustrated, above, are 10 ft. 6 in. high, with a diameter tapering from 4 ft. to 3 ft. 6 in. They weigh 14½ tons. The two principal people responsible for their production—Mr. Edwin Evans, the foreman patternmaker, and Mr. C. Rigby, the foreman moulder—are included in the picture. These castings have been made to the order of a large Canadian steel company.

Nickel-Chrome Resistance Alloy.

By C. H. S. T.

Very favourable results are reported with the nickel-chromium alloy made for resistance purposes. The "A" type of this alloy, which has been christened Chromel, is the first of its kind to employ so high a chromium content, namely, 20 per cent., the composition of the "A" alloy being 80 per cent. nickel and 20 per cent. chromium. It is claimed that this alloy resists oxidation more than any other base-metal combination and it is coming into use, especially in America, for electrical heating elements which work at temperatures between 760 deg. C. and 1,090 deg. C., and which are exposed to the atmosphere. Some of its specific applications are in ranges, radiant heaters, grills, hot plates and electric furnaces. This alloy is nearly iron-free, and this has been found an important factor in its durability.

Another variation in the same alloy, known as Chromel "B," has a nickel content of 85 per cent. and a chromium content of 15 per cent. It is somewhat less durable than "A," and is used where the conditions are less severe. At 23 deg. C. its electrical resistance is about 50 times that of copper.

The "C" alloy has an iron content of 25 per cent. and 11 per cent. chromium. It is not so resistant to oxidation as "A" and "B," though it finds an extensive application in flat-irons, toasters, and similar devices. It is also widely used for radio rheostats.

Chromel "D" consists of 8 per cent. chromium, 26 per cent. nickel, and 66 per cent. iron. This is cheaper than the other alloys, and is recommended for temperatures below a red heat. It is found very resistant to oxidation, and is largely used for rheostats.

To Clean Copper Castings.—Scour the whole surface well with a little muriatic acid and fine sand. When finished, rinse well with clean water and allow to dry naturally.

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Trade Talk.

MR. F. THOMAS lectured before the members of the Walsall Engineering Society last week on "Locomotive Injectors."

BOLCKOW, VAUGHAN & COMPANY, LIMITED, have an order from the Hull Corporation Tramways Committee for the supply of 500 tons of tram rails.

ON FRIDAY, November 20, Mr. G. E. Wills delivered a lecturette on the subject of the "Dehydration of Tar" before the Junior Institution of Engineers.

A PAPER ENTITLED "The Internal Combustion Boiler" was read last week by Mr. Oscar Brunler before the members of the Institute of Marine Engineers.

THE JAMES WATT MEMORIAL DINNER of the Institution of Engineers and Shipbuilders in Scotland has been held in Glasgow, Mr. A. J. Campbell, the president, presiding.

"THE EFFECT OF TEMPERATURES ON SOME OF THE PROPERTIES OF METALS" was the title of a lecture given to the members of the Sheffield Metallurgical Society last week by Mr. F. C. Lea.

THE SYNTHETIC AMMONIA & NITRATES, LIMITED, Billingham, Stockton-on-Tees, have placed a contract with the Darlington Forge, Limited, for a number of steel towers to the value of about £100,000.

THE STEEL MILLS at the Acklam Works of Dorman, Long & Company, Limited, Middlesbrough, which have been idle twelve months, have been restarted. The steel furnaces have already been operating for a fortnight.

DR. HYMAN, who is giving a paper before the Scottish Section of the Institute of Metals on December 14, has altered his subject from "Old Metallurgical Books in Glasgow Libraries" to "Aluminium and its Alloys for Engineering Purposes."

PRIOR TO DELIVERING his lecture on "The Trend of Engineering Progress" at the Liverpool University last week, Major-General Sir Philip A. M. Nash, chair-Engineering Progress" at the Liverpool University on Tuesday, Major-General Sir Philip A. M. Nash, chairman of Metropolitan-Vickers Electrical Company, Limited, visited the engineering laboratories of the University in company with Professor W. H. Watkinson.

THE DUBLIN DOCKYARD COMPANY (VICKERS-IRELAND, LIMITED), have secured a contract for the construction of a tug and pilot vessel from the Bluff Harbour Board, New Zealand. The dimensions of the vessel will be 135 ft. x 30 ft. x 20 ft., and she will be fitted with twin-screw semi-Diesel machinery by Vickers-Petters, Limited, capable of developing 1,200 b.h.p. Her speed on service will be 12 knots.

Personal.

MR. B. WALMSLEY and Mr. M. Mannaberg have been elected to seats on the board of Bolckow, Vaughan & Company, Limited.

VISCOUNT FURNESS has been elected chairman of the Weardale Steel, Coal and Coke Company, Limited, in place of the late Capt. J. E. Rogerson.

MR. H. ARMSTRONG, for several years London representative of the Lanarkshire Steel Company, Limited, has been appointed London manager of the Cargo Fleet Iron Company, Limited, and Cochrane & Company, Limited, both of Middlesbrough.

New Companies.

Mather (Wellingborough), Limited.—Capital £5,000 in £1 shares. Engineers and founders, etc. Directors: E. A. Fenwick and H. Richardson.

British and Overseas Trade and Engineering, Limited.—Capital £100 in 1s. shares. Solicitors: Reynolds & Sons, 7, Arundel Street, Strand, W.C.2.

General Foundry and Engineering Company, Limited.—Capital £10,000 in £1 shares. Directors: J. Livingston, Lawford Hill, near Rugby; D. Mitchell, F. Gray, and two others.

Death of Mr. W. H. Carder.—The death is announced at Ellesmere, Shropshire, of Mr. W. H. Carder, of Tividale Road, Tipton. Mr. Carder had long been associated with the iron and steel industries. He became secretary of the South Staffordshire Iron and Steel Institute when there arose the demand for a closer association between the practical and theoretical sides of the industry, and it was largely due to his organisation that the Institute (it is now known as the Staffordshire Iron and Steel Institute) became so influential. Mr. Carder was a director of the South Staffordshire Mond Gas Company.

Contracts Open.

Belfast, December 9.—Various, for the Belfast City and District Water Commissioners:—Hardware, iron castings, gunmetal couplings, caps and plugs. Mr. W. I. Quinn, secretary, Water Office, Belfast.

Belfast, December 5.—Sixteen-inch high pressure steam stop valve, for the Electricity Committee. Mr. J. Wright, city electrical engineer and manager, East Bridge Street, Belfast.

Buxton, December 5.—Materials, etc., for the Town Council:—Castings (street ironwork). Mr. F. Langley, borough engineer, Town Hall, Buxton.

Constantinople, December 31.—Three crane wagons, for the Chemin de Fer d'Anatolie-Bagdad. The Department of Overseas Trade. (Ref. A.X. 2580.)

Dundee.—Iron fencing, for the Dundee Town Council. Mr. G. Baxter, director of housing, 91, Commercial Street, Dundee.

Haslemere, December 7.—Extension of water mains, for the U.D.C.:—(Contract No. 1) 222 yards lineal of 4 in. diameter cast-iron pipe water main, together with sluice valve, hydrant, etc.; (2) 782 yards lineal of 4 in. diameter and 1,442 yards lineal of 3 in. diameter cast-iron pipe water main, together with hydrants, sluice valves, house connections, etc.; (3) 680 yards lineal 3 in. diameter cast-iron pipe water main, together with hydrants, sluice valves, etc.; (4) 140 yards lineal 3 in. diameter cast-iron pipe water main, together with hydrants, sluice valves, etc. Mr. C. A. Best, surveyor, Council Offices, West Street, Haslemere, Surrey. (Fee, £1 1s., returnable.)

Manchester, December 8.—Permanent-way special track work, for the Tramways Committee. Mr. H. Mattinson, general manager and chief engineer, Corporation Tramways, 55, Piccadilly, Manchester. (Fee £1 1s., returnable.)

Middlesbrough, December 5.—Stores, etc., for the Tees Conservancy Commissioners, viz., castings (steel and iron), bolts and nuts, brass and copper work. Mr. J. H. Amos, general manager, Head Office, Middlesbrough.

Sheffield, December 11.—Bridgework, for the Improvement Committee of the City Council. The Improvement Surveyor, Town Hall, Sheffield. (Fee, £3 3s., returnable.)

Thistleton, Lancs., December 5.—Bridgework, for the Lancashire County Council. Mr. W. H. Schofield, county surveyor and bridge-master, County Offices, Preston.

Obituary.

MR. O. BERRIDGE, managing director of Parsons, Sherwin & Company, Limited, agricultural engineers, Hinckley, died suddenly recently while on a visit to Derby.

SIR EDWARD PEARSON, the brother of Viscount Cowdray, and a director of S. Pearson & Son, Limited, contractors, died suddenly in London on November 19. The deceased joined the firm of S. Pearson & Son in 1900.

DR. BRINELL, the Swedish metallurgist, died recently. Dr. Brinell's scientific qualifications have earned for him a world-wide reputation. The Brinell test is one of the standard tests in the metallurgical world.

MR. G. A. JARVIS died recently at his residence, "The Shrubbery," Prior's Lee, Salop. The deceased gentleman had for a period of forty years been metallurgical chemist to the Lilleshall Company, Limited, at their Prior's Lee Iron and Steel Works. He was a man of repute in his profession, and was held in the highest regard by his employers and by the heads of the various departments.

The death occurred recently, at the age of 80, of Mr. John J. S. Toope, senior partner of the firm of Toope & Son, brass founders, Frankfort Street, Plymouth. Mr. Toope was probably the oldest brass founder in the country. Plymouth churches, and many in Cornwall and Devon, contain examples of Mr. Toope's work, and he was responsible for the lettering on the Smeaton Tower, which stands upon Plymouth Hoe.

MR. A. SHUTTLEWORTH, formerly chairman of the engineering firm of Clayton & Shuttleworth, Limited, died recently at Lincoln. Mr. Shuttleworth, who was a Deputy-Lieutenant and former High Sheriff of Lincolnshire, was in his 83rd year, and retired from the chairmanship of Clayton and Shuttleworth in 1919. The deceased was the eldest son of the late Mr. J. Shuttleworth, of Hartsholme Hall, Lincoln, and a nephew of the late Mr. N. Clayton of East Cliff, Lincoln, founders of Clayton and Shuttleworth. He was educated at Rugby and abroad, and early in life entered the engineering works at Lincoln. In 1869 he was admitted a partner.

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—Contrary to usual experience at this period of the year, business in the Cleveland iron market has taken an unexpectedly active turn, with an especially heavy turnover on forward account. This movement is consequent upon buyers' fears that an immediate advance in current prices may follow the increasing cost of production due to a rapid rise in fuel quotations. Export business also is improving, the Middlesbrough shipments for November, up to and including the 24th, having totalled 17,842 tons, compared with 14,090 tons to October 24. Still, whatever happens in regard to an advance, prices are not likely to fall further, and, convinced of that, buyers are now prepared to place contracts right up to the end of April, when the coal subsidy expires. Meanwhile, prices are very firm, 66s. 6d. per ton having been paid for No. 3 Cleveland G.M.B., and this appears now to be the general quotation. No. 1 foundry iron remains at 68s. 6d., No. 4 foundry at 65s. 6d., and No. 4 forge at 65s.

On the East Coast, as on the West, more hematite furnaces are being lighted up, and it is not a moment too soon. There has latterly been a very heavy demand, recent sales including a few parcels to U.S.A., but the big business anticipated has not yet matured. Still, makers have sold so heavily in other directions that quotations for East Coast mixed numbers have advanced to 75s. per ton, and for No. 1 hematite to 75s. 6d. West Coast prices, however, are unchanged, Bessemer mixed numbers remaining at £4 1s. 6d. c.i.f. Welsh ports, £4 5s. per ton delivered at Glasgow, £4 8s. 6d. per ton delivered at Sheffield, and £4 12s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—Inquiries in the Manchester market for foundry iron are not so good as previously reported, but this is probably the result of the recent buying, which could not be expected to continue, and if the present demand is not active, on the other hand, makers are not pushing sales. The principal foundry iron on offer is Derbyshire, and the price is steady at 73s. 6d. per ton delivered in this neighbourhood. There is also some small business doing in the district in Lincolnshire foundry iron at about 72s. 6d. per ton delivered.

THE MIDLANDS.—In South Staffordshire and the adjacent districts the demand for foundry pig still keeps up to quite a moderate level, and the ironfounders who contracted a few weeks ago for delivery over the remainder of the year are taking up quite good tonnages, and for the time being the blast furnaces are experiencing a little less anxiety in respect to their output. Current quotations are as follow:—Derbyshire No. 3 foundry, 65s.; Staffordshire No. 3 foundry, 65s.; Northants. No. 3 foundry, 62s. 6d.

SCOTLAND.—In this area demand continues on the slow side, without expansion in volume, consumers still confining their purchases to their immediate wants, with prices easy at 78s. for No. 3 foundry at the furnaces. There has been very little inquiry for Middlesbrough iron of late, and the few orders circulating have been very keenly competed for.

Finished Iron.

No change can be reported in the general conditions of the manufacturing departments of the iron trade, makers, with few exceptions, being anxious for fresh business, more especially makers of crown and the cheaper irons, who are badly hit by the foreign competition. It is quite impossible for the local ironworks to produce an iron to compete with the Belgian quotations, the latter works quoting round about £6 15s. per ton delivered South Staffordshire, whereas the local figure is £10 7s. 6d. per ton at the lowest. As a consequence of this, most of the business for nut and bolt iron is going abroad, although supplies from this quarter are getting somewhat belated and considerable difficulty is experienced in ensuring deliveries. The Staffordshire makers of crown iron are having to meet the Lancashire competition, and £11 10s. per ton to £11 12s. 6d. delivered is being quoted freely for this quality. There is no alteration in quotations for marked bars.

Steel.

The general condition of the industry has undergone little change since last reported, though the demand for semis may be slightly better, but, if so, it is hardly perceptible. The general quotation is still £6 for soft billets, which is about 12s. 6d. higher than the Continental product. The Welsh steelworks are confining their attention to the production of sheet and tinplate bars, for which there is a moderate and steady demand, in spite of the large quantities of foreign material imported. Prices remain unchanged at £6 5s., while foreign bars are offered at about £5 delivered. The works are not touching soft steel billets, owing to the keen competition of English and foreign makers. In the tinplate market there is a fair inquiry, but buyers seem to hesitate about paying makers' prices for next year's delivery. Business has been done on a basis of 19s. 10½d. to 20s., but there are not many sellers at the lower figure.

Scrap.

Some slight improvement may at last be recognised in the demand for cast scrap metal, and even in Lancashire, where business has long been quiet, the foundries are using more of this material, but there seems to be plenty available, with the exception of fine textile machinery quality, which is not very plentiful. For common qualities of cast iron 70s. per ton delivered is about the value, and for good, broken engine metal 72s. 6d. For the best "textile" scrap 75s. is usually asked by those dealers who have any to sell. Turnings and borings are worth very little now, and seem to attract scarcely any attention. Probably there is no margin of profit in dealing with them.

Metals.

Copper.—Conditions in this section of the base metal markets have been somewhat unsettled of late, due in part to the collapse of the franc, and also of the financial stringency in Germany. Until these two obstacles are removed, it is obvious that little, if any, upward movement will be registered in copper values, and, as a result, the market is without a stimulating influence, bearish arguments gaining the upper hand. Current quotations:—*Cash*: Thursday, £60 7s. 6d.; Friday, £60 7s. 6d.; Monday, £60 7s. 6d.; Tuesday, £60; Wednesday, £59 15s.

Three Months: Thursday, £61 7s. 6d.; Friday, £61 7s. 6d.; Monday, £61 7s. 6d.; Tuesday, £61; Wednesday, £60 15s.

Tin.—Considering the unquestionably stable statistical position of this metal, it is not surprising to note that, after depreciating several pounds from the recent yearly record price, values of tin have steadily improved, and finally established a level more in accordance with recent movements and conditions. Moderate purchases have been made on home and Continental account, and inquiries for near metal caused the premium on this position to increase. Current quotations:—*Cash*: Thursday, £286; Friday, £286 15s.; Monday, £288 15s.; Tuesday, £288; Wednesday, £286 5s.

Three Months: Thursday, £281 5s.; Friday, £281; Monday, £282 12s. 6d.; Tuesday, £282 7s. 6d.; Wednesday, £281.

Spelter.—During the last week or so the market for spelter has fluctuated, largely on account of greater willingness to sell on the part of the Continent, but values have now regained a considerable portion of the earlier loss. The undertone, however, still appears slightly hesitant, and if the statistical position in America were not sound, would no doubt slump materially. Current quotations:—*Ordinary*: Thursday, £39 10s.; Friday, £39 8s. 9d.; Monday, £39 1s. 3d.; Tuesday, £38 15s.; Wednesday, £38 6s. 3d.

Lead.—The position of soft foreign pig has been adversely affected to a certain extent by heavy arrivals, which have not been readily absorbed, and with the placing of some small quantities in warehouse, the market has been adversely affected, and the general trend has been downwards. Consumption has been on a much smaller scale during the last week or so, and seasonal slackness has been very apparent, but the demand from consumers is now a little more consistent. Current quotations:—*Soft foreign (prompt)*: Thursday, £35 17s. 6d.; Friday, £35 5s.; Monday, £36; Tuesday, £35 10s.; Wednesday, £34 18s. 9d.

"CAST IRON FOR DIESEL PURPOSES" was the subject of a lecture delivered by Mr. A. Marks at a meeting of the Glasgow Section of the Institute of British Foundrymen, held on Saturday last.

EXTENSIVE DAMAGE was caused by a fire which broke out on November 15 at the Panteg steelworks of Baldwins, Limited. Smoke was observed arising from the works garage, and the fire quickly reached the testing house, which was practically destroyed.

"SERVICE FIRST"

A HIGH NOTE.

The GENERAL REFRACTORIES Co. Ltd., Sheffield

We do not wish to make any sales merely for the sake of the profit to be derived from the first transaction nor wish you to pay for goods of which you do not approve.

YOUR INTEREST IS OUR STUDY

—OUR OWN WILL LOOK AFTER ITSELF.

Your satisfaction is our desire, and your recommendation to other Foundrymen is our aim. If we succeed in achieving it we shall have your regular business, and what is more to us, your confidence and your good word. On these terms we offer you our

UNIQUE

"MAXIMUM" CORE SAND

for either steel or iron. A clean, sharp, free-running sand, most pleasurable to handle. Free from all manner of impurities, and asking for a minimum of core binder. There is no core sand like this on the market, and dissatisfied customers are unknown.

Please ask for price and sample.

BCM/OK9 LONDON.

This is our British Commercial Monomark. Envelopes addressed simply as such will be duly delivered to us by special arrangement with the Post Office.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	59	15	0
Three months	60	15	0
Electrolytic	66	5	0
Tough	62	15	0
Best selected	64	5	0
Sheets	92	0	0
India	79	0	0
Wire bars	67	0	0
Do. Dec.–Jan.	66	15	0
Do. Jan.	66	15	0
Ingot bars	66	15	0
H.C. wire rods	71	5	0
Off. av. cash, Nov. 61	6	10	1/2
Do., 3 mths. Nov. 62	6	3	
Do., Sttlmnt, Nov. 61	6	5	1/2
Do., Electro, Nov. 68	2	10	3/4
Do., B.S., Nov.	65	10	0
Aver. spot price copper, Nov.	61	6	5
Do., wire bars, Nov. 68	7	10	1/2
Solid drawn tubes		13	1/2d.
Brazed tubes		13	1/2d.
Wire			10d.

BRASS.

Solid drawn tubes	12d.
Brazed tubes	13 1/2d.
Rods, drawn	11 1/2d.
Rods, extd. or rlld.	7 1/2d.
Sheets to 10 w.g	10 3/4d.
Wire	10 1/2d.
Rolled metal	10 1/2d.
Yellow metal rods	7 1/2d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8 1/2d.

TIN.

	£	s.	d.
Standard cash	286	5	0
Three months	281	0	0
English	285	10	0
Bars	290	0	0
Straits	293	0	0
Australian	292	0	0
Eastern	291	15	0
Banca	296	0	0
Off. aver. cash, Nov.	284	14	1 1/2
Do., 3 mths., Nov.	281	14	9 1/2
Do., Sttlmt. Nov.	284	13	6 1/2
Aver. spot., Nov.	284	13	7

SPELTER.

	£	s.	d.
Ordinary	38	6	3
Remelted	37	0	0
Hard	32	5	0
Electro 99.9	42	17	6
English	39	7	6
India	33	5	0
Zinc dust	45	0	0
Zinc ashes	15	0	0
Off. aver., Nov.	38	13	5 1/2
Aver., spot, Nov.	39	0	9 1/2

LEAD.

	£	s.	d.
Soft foreign ppt.	34	18	9
English	36	5	0
Off. average, Nov.	36	10	10
Average spot, Nov.	36	17	5 1/2

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	46	10	0
Do. V.M. ex whf.	45	10	0
Rods	53	0	0
Boiler plates	44	10	0
Battery plates	45	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	89	10	0
Chinese	81	0	0
Crude	63	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	14	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon 45/50%	£11 14 0
75%	£21 10 0
Ferro-vanadium—35/40%	15/6 lb. va.
Ferro-molybdenum—70/75% c. free	6/– lb.
Ferro-titanium—23/25% carbonless	1/1 lb.
Ferro-phosphorus, 20/25%,	£22 0 0
Ferro-tungsten—80/85%,c.fr.	1/7 1/2 to 1/8 lb.
Tungsten metal powder—98/99%	1/10 1/2 to 1/11lb.
Ferro-chrome—4/6% car.	£23 12 6
6/8% car.	£23 2 6
8/10% car.	£22 15 0
Ferro-chrome—Max. 2% car.	£40 10 0
Max. 1% car.	£49 0 0
Max.0.70%car.	£56 10 0
70%, carbonless	1/5 lb.
Nickel—99%, cubes or pellets	£172 to £177
Cobalt metal—98/99%	10/– lb.
Aluminium 98/99%	£120
Metallic Chromium—96/98%	3/9 lb.
Ferro-manganese (net)—76/80%, loose	£15 7 6
76/80%, packed	£16 7 6
76/80%, export	£15 5 0
Metallic manganese—94/96%, carbonless	2/– lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 2 6
Finished bars, 18% tungsten	3 0

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. and over .. 4d.lb.
Rounds and squares under 1/2 in. to 1/4 in. 3d. lb.
Do. under 1/4 in. to 1/8 in. .. .. 1/– lb.
Flats, 1/4 in. × 1/4 in. to under 1 in. × 3/8 in. 3d. lb.
Do. under 1/4 in. × 1/4 in. 1/– lb
Bevels of approved sizes and sections 6d. lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces .. .. 3d.
Turningds andwarf 1d.

Per lb. net, d/s steel makers' work

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel		3	10	0		
Bundled steel & shrngs.	3	2	6	to 3	6	6
Mixed iron & steel	3	2	6	to 3	3	6
Heavy cast iron	3	5	0	to 3	6	0
Good machinery for foundries	3	7	6	to 3	12	6
Cleveland—						
Heavy steel		3	0	0		
Steel turnings		2	0	0		
Cast iron borings		1	17	6		
Heavy forge		4	0	0		
Bushelled scrap		3	0	0		
Cast-iron scrap	3	0	0	to 3	1	0
Lancashire—						
Cast-iron scrap	3	10	0	to 3	12	6
Heavy wrought		3	7	6		
Steel turnings		2	0	0		

London — Merchants' buying prices delivered yard.

Copper (clean)	53	0	0
Brass (clean)	40	0	0
Lead (less usual draft)	33	0	0
Tea lead	29	0	0
Zinc	27	0	0
New aluminium cuttings	92	0	0
Braziery copper	48	0	0
Gunmetal	47	0	0
Hollow pewter	195	0	0
Shaped black pewter	142	0	0

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/6
Foundry No. 4	65/6
Forge No. 4	65/–
Hematite No. 1	75/6
Hematite M/Nos.	75/–
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/–
,, d/d Birm.	92/6
Midlands—	
Staffs common*	—
,, No. 4 forge	59/6
,, No. 3 foundry	65/–
Shrops. basic	70/–
,, Cold blast, ord.*	185/–
,, ,, roll iron*	190/–
* d/d Birmingham.	
Northants forge	56/–
,, fdry No. 3	62/6
Derbyshire forge	59/6
,, fdry. No. 3	65/–
,, basic	65/–
Scotland—	
Foundry No. 1	83/–
,, No. 3	78/–
Hem. M/Nos.	77/6
Sheffield (d/d district)—	
Derby forge	63/6
,, fdry. No. 3	68/–
Lincs. forge	68/–
,, fdry. No. 3	70/–
E.C. hematite	85/6
W.C. hematite	88/6
Lincs. (at furnaces)—	
Forge No. 4	62/–
Foundry No. 3	64/–
Basic	64/–
Lancashire (d/d eq. Man.)—	
Derby forge	67/–
,, fdry. No. 3	73/6
Northants foundry No. 3	75/3
Dalzell, No. 3	110/–
Summerlee, No. 3	95/6
Glengarnock, No. 3	95/6
Gartsherrie, No. 3	95/6
Monkland No. 3	95/6
Coltness, No. 3	95/6
Shotts, No. 3	95/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars(cr.)	11	5	0	to 12	10	0
Angles				11	10	0
Tees to 3 united ins.				12	0	0
Nut and bolt				11	0	0
Hoops	14	0	0	to 15	0	0
Marked bars (Staffs.) f.o.t.				14	10	0
Gas strip	12	10	0	to 12	15	0
Bolts and nuts 3/4 in. × 4 in.				16	15	0
Steel—						
Ship plates	7	5	0	to 8	7	6
Boiler plts.				11	10	0
Chequer plts.	£9	5	0	to 9	15	0
Angles	£7	0	0	to 7	5	0
Tees	£8	0	0	to 8	5	0
Channels	£6	15	0	to 7	5	0
Joists	£7	0	0	to 7	5	0
Rounds and Squares 3 in. to 5/8 ins.				8	10	0
Rounds under 3 in. to 3/8 in.				8	5	0
Flats, over 5 in. wide and up				9	0	0
Flats, 5in. to 1 1/2in.				8	0	0
Rails, heavy				8	0	0
Fishplates				12	0	0
Hoops (Staffs.)				10	10	0
Black sheets, 24g.				11	5	0
Galv. cor. sheets, 24g.				16	12	6
Galv. fencing wire 8g. plain				14	0	0
Billets,soft	£6	0	0	to 7	10	0
Billets, hard				8	2	6
Sheet bars				6	5	0
Tin bars d/d				6	5	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3 1/2
Wire	1	4
Rods	1	3
Tubes	1	8 1/2
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

Per lb.
Ingots for raising 9d. to 1/3
Rolled—
To 9 in. wide 1/3 to 1/9
To 12 in. wide 1/3 1/2 to 1/9 1/2
To 15 in. wide 1/3 1/2 to 1/9 1/2
To 18 in. wide 1/4 to 1/10
To 21 in. wide 1/4 1/2 to 1/10 1/2
To 25 in. wide 1/5 to 1/11
Ingots for spoons and forks .. 9d. to 1/5 1/2
Ingots rolled to spoon size .. 1/– to 1/8 1/2
Wire round—
3/0 to 10 G. 1/6 1/2 to 2/1 1/2
with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	23.76
No. 2 foundry, Valley	22.26
No. 2 foundry, Birm.	21.00
Basic	21.76
Bessemer	22.76
Malleable	22.26
Grey forge	21.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila.	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.50
Sheets, black, No. 28	3.25
Sheets, galv., No. 28	4.50
Sheets, blue an'l'd, 9 & 10	2.40
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry .. 32/6 to 37/6
,, furnace .. 20/– to 25/–
Durham & North.
,, foundry 30/– to 33/–
,, furnace .. 16/–
Other Districts, foundry 30/– to 33/–
,, ,, furnace (basis) 11/9

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20 × 14, box	20/1 1/2
,,	28 × 20, ,,	40/3
,,	20 × 10, ,,	29/4 1/2
,,	18 3/4 × 14, ,,	20/10 1/2
C.W.	20 × 14, ,,	18/3
,,	28 × 20, ,,	36/6
,,	20 × 10, ,,	25/4 1/2
,,	18 3/4 × 14, ,,	18/10 1/2

Terneplates 28 × 20, 36/3 per box basis f.o.b.

SWEDISH IRON.

Bars, hammered £19/0 to £20/0
Rolled Ord. £16/0/0 to £16/10/0
Nail rods £16 5 0 to £16 15 0
Keg. steel nom. £33 to £35
Faggot steel nom. £22 to £25
Blooms, according to quality £10 to £14
Pig-iron £6 15 0 to £7 0 0 all f.o.b. Gothenburg.

TUBES.

Up to and incl. 6 in.

Gas .. 55% } Tube prices
Water .. 50% } are
Steam .. 45% } now free.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Nov. 26	60	7	6	inc. 5/-
,, 27	60	7	6	No change
,, 30	60	7	6	,, ,,
Dec. 1	60	0	0	dec. 7/6
,, 2	59	15	0	,, 5/-

Electrolytic Copper.

	£	s.	d.	
Nov. 26	67	0	0	inc. 5/-
,, 27	67	0	0	No change
,, 30	67	0	0	,, ,,
Dec. 1	66	15	0	dec. 5/-
,, 2	66	5	0	,, 10/-

Standard Tin (Cash).

	£	s.	d.	
Nov. 26	286	0	0	inc. 15/-
,, 27	286	15	0	,, 15/-
,, 30	288	15	0	,, 40/-
Dec. 1	288	0	0	dec. 15/-
,, 2	286	5	0	,, 35/-

Tin (English ingots).

	£	s.	d.	
Nov. 26	286	0	0	inc. 10/-
,, 27	286	10	0	,, 10/-
,, 30	288	10	0	,, 40/-
Dec. 1	288	0	0	dec. 10/-
,, 2	285	10	0	,, 50/-

Zinc Sheets (English).

	£	s.	d.	
Nov. 26	46	10	0	No change
,, 27	46	10	0	,, ,,
,, 30	46	10	0	,, ,,
Dec. 1	46	10	0	,, ,,
,, 2	46	10	0	,, ,,

Spelter (ordinary).

	£	s.	d.	
Nov. 26	39	10	0	No change
,, 27	39	8	9	dec. 1/3
,, 30	39	1	3	,, 7/6
Dec. 1	38	15	0	,, 6/3
,, 2	38	6	3	,, 8/9

Lead (English).

	£	s.	d.	
Nov. 26	37	0	0	No change
,, 27	37	10	0	inc. 10/-
,, 30	37	5	0	dec. 5/-
Dec. 1	36	10	0	,, 15/-
,, 2	36	15	0	,, 5/-

AVERAGE MONTHLY PRICES OF STEEL BOILER PLATES IN ENGLAND.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	5 15 0	5 15 0	5 12 6	5 12 6	5 15 0	5 17 6	5 15 0	5 17 6	6 0 0	6 0 0	6 2 6	6 0 0	5 16 10½
1896	6 0 0	6 0 0	6 2 6	6 2 6	6 2 6	6 0 0	6 0 0	6 0 0	6 0 0	6 2 6	6 10 0	6 10 0	6 2 6
1897	6 10 0	6 10 0	6 10 0	6 7 6	6 2 6	6 2 6	6 5 0	6 0 0	6 0 0	6 0 0	6 7 6	6 10 0	6 5 5
1898	6 10 0	6 8 9	6 8 9	6 10 0	6 15 0	6 18 9	6 17 6	6 17 6	7 2 6	6 15 0	7 0 0	7 5 0	6 15 8½
1899	7 5 0	8 0 0	8 2 6	8 2 6	8 5 0	8 5 0	8 12 6	8 12 6	8 15 0	8 15 0	9 2 6	9 5 0	8 17 8½
1900	9 5 0	9 5 0	9 7 6	9 10 0	9 12 6	10 5 0	10 5 0	10 5 0	10 5 0	10 0 0	9 15 0	9 15 0	9 15 10
1901	9 5 0	9 5 0	8 15 0	8 10 0	8 10 0	7 10 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 3 11
1902	7 7 6	7 0 0	7 12 6	7 12 6	7 12 6	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 9 7
1903	7 10 0	7 10 0	7 15 0	7 5 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	6 17 6	7 3 11½
1904	6 12 6	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 11½
1905	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 17 6	6 10 0	7 5 0	8 0 0	8 0 0	7 1 3
1906	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 10 0	8 0 10
1907	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 10 0	8 0 0	8 0 0	8 8 4
1908	7 10 0	7 10 0	7 10 0	7 5 0	7 5 0	7 5 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 3 9
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	6 15 0	6 15 0	6 15 0	7 0 0	7 0 0	7 0 0	7 0 0	6 18 9
1910	7 0 0	7 0 0	7 1 3	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 10 0	7 10 0	7 10 0	7 5 1
1911	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 10 0	7 14 0	7 10 4
1912	7 18 9	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 15 0	8 16 3	9 0 0	9 2 0	9 5 0	8 11 2½
1913	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	8 19 0	8 15 0	8 5 0	7 15 0	7 15 0	8 17 0
1914	7 15 0	7 15 0	7 15 0	7 13 9	7 10 6	7 5 0	7 0 0	8 0 0	8 2 6	8 5 0	8 5 0	8 5 0	7 15 11½
1915	8 14 0	9 10 0	9 17 6	10 10 0	10 10 0	11 0 0	11 0 0	11 0 0	11 0 0	11 4 0	12 0 0	13 0 0	10 15 5½
1916	13 0 0	13 0 0	13 0 0	12 15 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 12 11
1917	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1918	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0	12 10 0
1919	13 0 0	15 0 0	15 0 0	15 0 0	19 5 0	19 17 6	21 0 0	21 10 0	21 10 0	21 10 0	21 15 0	23 10 0	18 9 9
1920	26 0 0	28 0 0	28 5 0	28 10 0	29 5 0	30 0 0	30 0 0	30 0 0	30 10 0	31 0 0	31 0 0	31 0 0	29 9 2
1921	30 5 0	29 0 0	25 0 0	25 0 0	23 0 0	21 0 0	20 10 0	19 0 0	17 10 0	16 0 0	14 16 0	22 1 9
1922	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	13 1 8	13 10 0	12 15 0	12 10 0	12 10 0	12 10 0	12 6 0	13 10 9
1923	12 8 9	13 6 0	14 0 0	14 0 0	14 0 0	13 12 6	13 0 0	13 0 0	13 0 0	13 0 0	13 0 0	13 10 0	13 9 1½
1924	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	13 10 0	14 0 0	14 0 0	13 11 0	13 5 0	13 5 0	13 10 11
1925	13 5 0	13 5 0	13 5 0	13 1 0	12 15 0	12 15 0	12 15 0	12 15 0	12 7 6	11 14 0	11 10 0	—	—

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